

Beyond Imagination: Leveraging Generative AI to Enhance Learning through Story World Analogies

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Abstract—This innovative practice full paper describes *ConceptualTales*, a conversational AI that explains STEM and social science concepts using analogies from popular story worlds and Socratic reasoning. The disconnect between conventional teaching strategies and student engagement is a persistent challenge in educational systems, particularly STEM fields. Traditional methods often fail to resonate with students, rendering the learning process monotonous and detached from their personal interests. Concurrently, students are enthusiastic about and dedicated to fictional worlds such as Marvel, Harry Potter, and Disney. This observation forms the basis for our innovative practice: integrating these beloved narratives into educational content through generative AI. *ConceptualTales* was tried with middle and high school students in the USA and China and received overwhelmingly positive feedback. Our system combines fiction-inspired learning, analogical reasoning, and Socratic questions, to make educational content personal and interesting to students.

Index Terms—analogies, concepts, generative AI, story worlds, narratives, artificial intelligence in education (*AlinEd*)

I. INTRODUCTION

A. Personalized Learning and Engagement with Story Worlds

Personalization of learning content and students’ perception of choice have long been shown to learning engagement and academic performance [1], [13], [63]. Traditionally, educational design has adhered to a “one size fits all” approach, often out of necessity due to limited technological and personnel resources [2]. This model frequently leaves students feeling disconnected from their learning material, struggling to see its relevance to their personal interests [3], [5]. Teachers, in turn, face challenges in motivating students and igniting their curiosity about academic subjects [3], [9].

In contrast, children and teenagers dedicate substantial time and effort to exploring story worlds and related entertainment forms. For instance, 85% of U.S. teens play video games and about 40% engaging daily, immersing themselves in fictional game worlds [43]. These story worlds or universes—terms used interchangeably here—are expansive fictional realms

featuring interconnected stories, diverse characters, unique locations, and intricate mythologies. Iconic story universes such as Harry Potter and Marvel captivate audiences with their depth and creativity. Even reality TV shows and influencer-based content may function as modern variations of these fictional story worlds. Daily smartphone use for U.S. teenagers averages around four hours, with online video platforms like YouTube being particularly popular [6]- [8].

B. Benefits of Fiction-Inspired Learning

The human predisposition towards narrative structures is deeply rooted in cognitive development and evolutionary history, shaped by storytelling-dependent social structures [18], [19]. Narratives serve as a fundamental mechanism for organizing human experience and making sense of the world, a role supported by a breath of empirical research in cognitive psychology and anthropology [18], [20]. Neuroscience studies show that engaging with stories activates brain regions linked to sensory experiences, emotion, and empathy, aiding social cognition and learning [21], [22]. In educational contexts, storytelling can make abstract concepts more concrete and memorable, improving comprehension and retention [23], [24]. The presence of characters in narratives enhances identification, making messages more persuasive and relatable [25], [26].

Fiction-inspired learning significantly enhances creativity, motivation, and engagement in students. Science fiction, for instance, encourages critical thinking by exploring “what-if” scenarios that bridge the gap between abstract scientific concepts and practical applications [10]. Integrating narrative-based learning into educational activities immerses students in fantasy contexts, making learning more relatable and enjoyable [12], [13]. In a university class at McMaster University, Wong et al. [11] showed that analyzing scientific characters encourages students to apply scientific thinking across subjects and increases student confidence in their scientific inquiry skills. Additionally, storytelling fosters cognitive and cultural

development, improves language acquisition, and supports academic success, especially when combined with constructivist and culturally relevant approaches [14]. Moreover, engaging with speculative and optimistic fiction helps students understand scientific principles and their ethical implications, promoting transformative learning [15], [16]. Initiatives like the Smithsonian’s STEM + L (Literacy) project have successfully integrated fiction-inspired learning into STEM educational materials, demonstrating effectiveness in engaging diverse student populations and improving STEM learning outcomes [17].

C. Using Analogies for Teaching

Analogies are a powerful pedagogical tool, facilitating the understanding of new concepts by relating them to familiar ones [27]. Historically, analogies have been integral in various educational practices, from ancient Chinese and Greek teachings to religious parables and mnemonic devices [28], [29], [52]. Modern research underscores the effectiveness of analogies in enhancing conceptual understanding and retention, particularly in science education [30]. Saxena et al. [56] developed a set of analogies from everyday life for teaching university-level concepts in Computer Science. 32 students reported concepts taught via analogies to be easier to understand, with an average rating of 4.4 on a Likert scale. Implementing analogies from fictional worlds further engages students by making learning more relatable and stimulating critical thinking and problem-solving skills [32], [33]. For instance, analogies help students grasp complex scientific ideas, such as using Harry Potter’s spells to explain chemical reactions [31]. However, educators must be careful to select and explain analogies to avoid misconceptions and ensure accurate understanding [34], [35].

D. Generative AI for Educational Analogies

However, creating personalized, fiction-based analogies presents significant challenges for educators. Teachers cannot be expected to master the myriad story worlds that each student might be passionate about, nor do they have the time to develop specific analogies for each concept in real-time. This creative synthesis process is both mentally demanding and time-intensive. Advanced generative AI tools, such as ConceptualTales, address these challenges by leveraging the capabilities of large language models (LLMs). LLMs excel at creative synthesis, bridging concepts from different disciplines and contexts by analyzing vast amounts of data to identify patterns, relationships, and connections that may not be immediately obvious to human researchers [36], [37]. One of the key techniques LLMs use to achieve this is embeddings. Embeddings are a way to represent words, phrases, or even entire concepts as vectors in a high-dimensional space. These vectors capture semantic relationships, meaning that words with similar meanings or contexts are located closer together in this space [38], [39]. For instance, in this vector space, "wizard" might be close to "magic" and "Harry Potter" because these concepts frequently appear together and share similar contexts. This allows the AI to understand

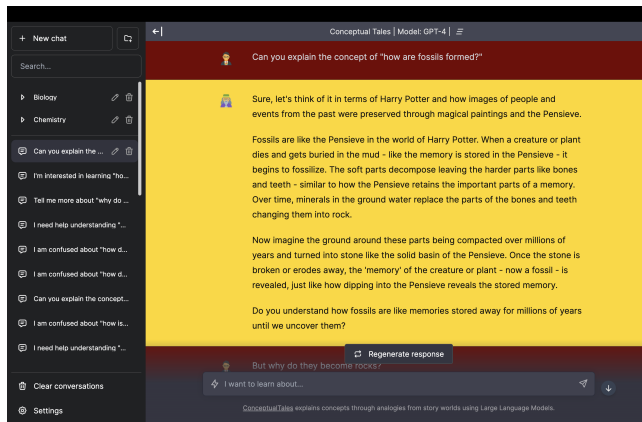


Fig. 1. Screenshot of a conversation with ConceptualTales, explaining fossil formation with an analogy from Harry Potter. The chatbot likens the burying of dead plants to the storing of old memories in Dumbledore’s Pensieve.

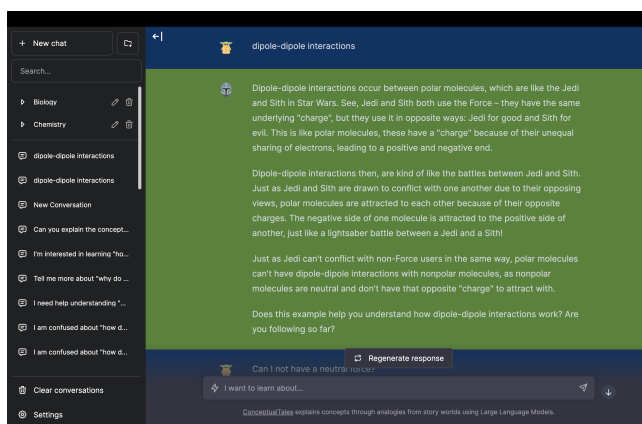


Fig. 2. Screenshot of a conversation with ConceptualTales, exploring dipole-dipole interaction with an analogy from Star Wars. The chatbot compares positive and negative charges with the Jedi and the Sith.

and generate analogies that are contextually relevant and coherent, making the learning experience more engaging and personalized for students [40], [41]. For instance, to explain the concept of genetic inheritance, an analogy can be drawn from Harry Potter: just as Harry inherits magical abilities from his parents, traits such as eye color or susceptibility to certain diseases are passed down from parents to offspring through genes. By utilizing these embeddings, LLMs can efficiently integrate diverse information sources and craft novel, insightful analogies that resonate with students’ existing knowledge and interests.

Our Conversational AI tool, ConceptualTales, uses the knowledge base and creative synthesis abilities of large language models (LLMs) to create analogies between educational content and students’ favorite fictional realms, such as Fortnite and Game of Thrones. In addition to providing information, the chatbot encourages reflective thinking through Socratic reasoning [42]. In workshops with middle and high school students, ConceptualTales was used both independently and

integrated into classroom curricula. Feedback was largely positive, with students and teachers expressing eagerness to use the tool again. We propose integrating ConceptualTales into classrooms, where teachers can prompt students to explore concepts via the tool and share insights from various story worlds in peer discussions.

II. METHODOLOGY

A. Technical Design & Application Overview

ConceptualTales was developed using the open-source Chatbot UI [45], which mimics OpenAI’s ChatGPT UI. We added a drop-down menu that enables students to select from a curated list of popular story worlds. The list was compiled based on suggestions from students and fellow educators, aligning with the preferences of 12 to 17-year-olds. Students also had the option to type in their own story world or pick from a random universe by leaving their selection blank. They were then prompted to ask questions they had about any topic.

To assist students who may be unsure about what to ask, we added alternating prompt suggestions that encourage scientific exploration. Once the user poses a question, a new chat is initiated, and the chatbot crafts an answer by drawing upon an analogy from the selected narrative universe. The conversation is saved in a sidebar folder structure that enables organization into subfolders for easy sorting by subject.

Depending on the story world, we customized the chat interface with related colors and icons for the AI assistant and the human user. For instance, chat utilizing the Harry Potter universe would be colored in Gryffindor’s signature crimson hue. The user’s icon would embody Harry Potter, the protagonist, while the AI assistant was symbolized by Professor Dumbledore, a powerful wizard and mentor within the Harry Potter world.

We aimed to choose reasonable icons for a student-teacher relationship, where possible. However, while it has been shown that teaching mediated by AI-generated characters improves learning and well-being in students, the AI we used did not embody the icon character directly [44]. We emphasized offering diverse analogies from the story universe at large, rather than role-playing with individual characters.

For the large language model, OpenAI’s GPT-3.5 Turbo [46] with training data up until September 2021 and GPT-4 Turbo [47] with training data up until December 2023 were used. We used in-context learning and no fine-tuning to deliver the chatbot’s responses.

The system prompt (see Appendix 1) instructed the model to explain the student’s questions with analogies from the selected story world or an alternative popular story world if none was supplied. Additionally, the model was instructed to ask probing questions and progress in depth and complexity as the conversation evolved.

B. Intended Usage in the Classroom

While ConceptualTales can be used by students on their own, we aim for its use in a teacher-guided environment. It therefore functions as a supplement to students understanding

TABLE I
PERSONALIZED FEATURES ON CONCEPTUALTALES

Feature	Function
Dropdown	Allows users to pick between suggested story worlds as well as inputting their own favorite story worlds
Suggested prompts	Allow users to gain familiarity with how they can go about asking questions and experience the UI
Folders	Students can organize certain chats into different subject areas
Styling Personalizations	Users can select story worlds with designated story world character icons and colors

a concept in depth, rather than a replacement for classroom education. Whether in regular or after-school classes, instructors can propose new topics to be learned, which students then explore using ConceptualTales. Students should then be encouraged to have discussions with other classmates about the new concept, and the instructor could step in to clarify misunderstandings as well as provide more formal education for the concept. Since large language models occasionally produce misinformation, called hallucinations [49], teachers should verify the scientific facts and statements generated by the AI.

C. Workshops

We conducted two workshops with middle and high school students in the USA and China. The workshop in the United States focused on using ConceptualTales in an after-school class to freely explore topics from their regular classes under teacher guidance. In the Chinese workshops, ConceptualTales was featured as an integral part of a regular class. Since UNESCO guidelines recommend that students no younger than age 13 should interact with artificial intelligence [48], both workshops were conducted with students who were either in middle or high school.

The first workshop of about one hour took place at a U.S. public charter school and comprised seven ethnically and culturally diverse students aged 15 to 18 years. Nearly half the students came from economically disadvantaged homes, and many were English-language learners, some of whom were several years below grade level. Each student had their own desktop PC with the application open. Their teacher visited each desk periodically and verbally guided students through the usage of ConceptualTales, encouraging them to explore and discuss various homework topics. In the first half of the workshop, ConceptualTales used OpenAI’s GPT-3.5 [46] model to generate answers and switched to GPT-4 in the second half. Students were tasked to write a thematic essay based on their chosen topic and story world(s).

The second workshop occurred in a private international school in Beijing, China. Eight students aged 15 to 17 years old and fluent in English used ConceptualTales as part of their regular International Baccalaureate (IB) lesson in Chinese Language and Literature. The students were ethnically predominantly Asian and from middle-class families. Most also

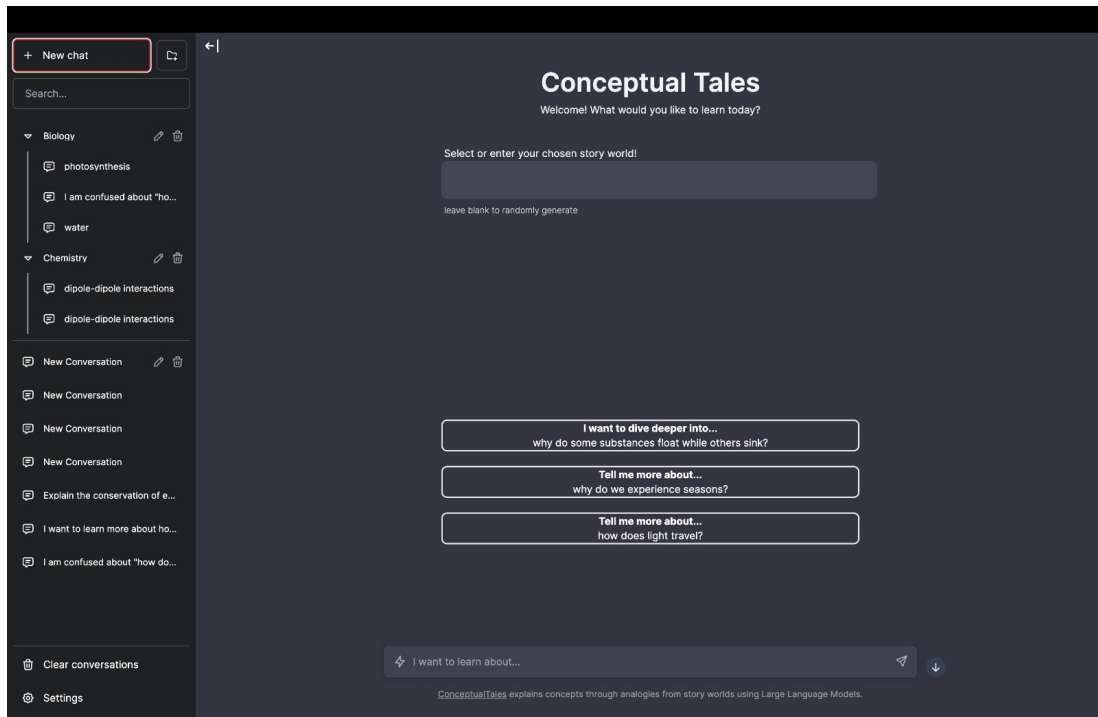


Fig. 3. Upon accessing the ConceptualTales interface, students can select or type their desired story world into a dropdown menu. If the menu is left blank, a random story world is chosen. Dynamically changing starting questions from the STEM and social sciences are proposed to get the students started. Students can organize their chats into folders by subject on the left-hand menu bar.

were English-language learners. In the lesson that ConceptualTales was used, the class analyzed complex global issues, while having their laptops open and using the application in parallel. Students discussed terms such as “absurdity,” “utopia,” “overlooked,” and “coexistence” relevant to various global issues. They then explored these terms in the context of the story worlds that interested them.

D. Data Collection

The study employed several methods of self-reporting and think-aloud data collection. Both workshops were run by the regular teachers of the respective classes, while the research team witnessed and heard the participants interacting with their teacher and the ConceptualTales prototype over Zoom. Teachers received in-depth explanations of the chat-bot tool and usage prior and captured student feedback after class.

The teacher guided them through the interaction with the prototype by asking students questions about their experience with the prototype. Likewise, the researchers also asked the teacher and students questions about the prototype via Zoom.

At the end of the session, the teacher asked the students to record their reactions in handwriting to having used the prototype, including listing improvements they would like to see in the future. Lastly, a follow-up interview with the instructor revealed more information regarding the learning-teaching experience.

III. RESULTS

A. Workshop 1

Students explored a variety of topics, ranging from discrimination to dipole-dipole interactions in chemistry. The following is an overview of the students’ and teacher’s feedback.

1) *Engagement and Interactivity*: Students rated their interaction with ConceptualTales highly, with an average enjoyment score of 9.5 out of 10. Feedback indicated that students found the tool engaging and enjoyable to use. For instance, one student mentioned, “This was really fun to do. Once this becomes more advanced, I’d really like to learn from it,” and another noted, “Overall, I would say this was a really fun experience and a really creative program that was exciting to use.”

2) *Exploration of Story Worlds*: On average, each student explored 4-5 different story worlds, ranging from Western science fiction and comics-based films to manga and video games. Many students experimented by adding their own story worlds or leaving the story world selection field blank. This flexibility allowed for creative exploration, with some students even suggesting the inclusion of more in-character dialogue responses to enhance their experience. As one student said, “The specific examples it gives are really helpful in learning. The specific character and universes can make you feel comfortable with learning the subject.”

3) *Effectiveness of Analogies and Contexts*: Feedback on the analogies provided by ConceptualTales was overwhelmingly positive, with many expressing eagerness to use Con-

ceptualTales again. Students appreciated the detailed and contextually relevant examples. Comments included:

- "Good examples, though it starts off vague and becomes more detailed."
- "Really clear analogy and shows an understanding of the lore."
- "The tool was really useful and made it easy to understand things."
- "Analogies make more sense and I like the question at the end."

However, some students noted that the analogies became less focused over time and less detailed when unrelated to science topics. Students also observed that the tool provided more in-depth analogies when using pre-built story worlds than custom ones. The use of Socratic Reasoning was also observed, with students noting the "thought-provoking questions at the end." The analogies generated by the GPT-4 model were rated as even better and more accurate. There was a notable interest in the possibility of interacting with specific characters from favorite fictional worlds.

4) *Accessibility and Inclusivity*: One student experienced difficulties perceiving the color choices in the presentation of the tool, mentioning that certain shades of yellow in the Pokemon story world text and background were too similar, making the text hard to discern. This was especially problematic for one student who reportedly experienced colorblindness.

5) *Areas for Improvement*: Suggestions for improvement included asking for more detailed and varied analogies and more interactive character-driven dialogues. One participant mentioned that the tool was more insightful when the input explicitly fits within its pre-built frameworks, especially for scientific topics. Researchers also noted that students often typed only a few words about the topic they wanted to learn, which suggests a need for better guidance on how to interact with the tool effectively.

Overall, participants reported a positive learning experience, some commenting that the tool was helpful and creative, and aided in participant understanding of topics that were previously confusing, especially in STEM-related subjects.

B. Workshop 2

In the second workshop, students engaged with various global and intercultural issues, using terms such as "absurd," "utopia," "overlooked," "coexistence," "trauma," and "generational" as their search keywords. They explored texts from anime and films that piqued their interest. The following provides an overview of student and teacher feedback.

1) *Engagement and Interactivity*: Students rated their interaction with ConceptualTales highly, with scores ranging from 6 to 9 out of 10. The average enjoyment score was 7.7 out of 10. Feedback indicated that while students found the tool engaging, there was room for deeper discussion. For example, one student remarked, "Adds width to discussion. Not depth though." Another noted, "Gives me many new ideas, like the definition of 'absurdity.'" A third student highlighted the tool's effectiveness in inspiring their internal oral assessments,

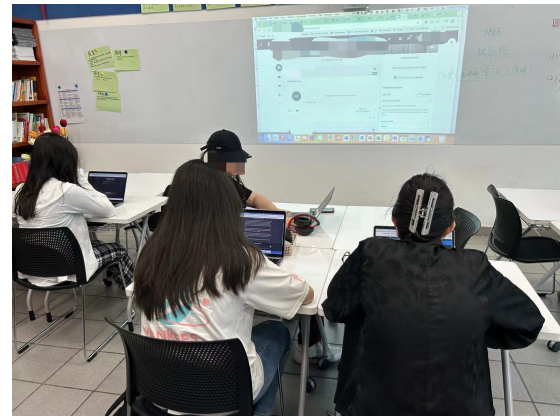


Fig. 4. Students using ConceptualTales in the classroom in a Chinese Language and Literature class in Workshop 2. ConceptualTales is used as a tool in the regular class to enrich the discussion on intercultural issues.

saying, "Very effective. Gives me a lot of inspiration on my internal oral assessment."

2) *Exploration of Story Worlds*: Students explored a variety of story worlds, primarily from movies and games. However, some students expressed a desire for more diverse themes. One student commented, "Would love to see more themes of the story world besides movies and games. When I use the tool, I have to research some characters to understand the context."

3) *Effectiveness of Analogies and Contexts*: The analogies and contexts provided by ConceptualTales were well-received, particularly in helping students understand complex concepts. The teacher observed that using well-known texts like "Star Wars" helped students grasp "generational" issues effectively, especially through the father-son "loyalty" dilemma. This familiarity allowed students to quickly understand the concepts and reflect on overlooked perspectives in their writing. Furthermore, students discovered that approaching texts from different conceptual angles helped them understand that such "concepts" are commonplace in everyday life.

4) *Accessibility and Inclusivity*: There were no specific comments on accessibility and inclusivity in this workshop.

5) *Areas for Improvement*: Students and teachers suggested several areas for improvement. Students desired more varied themes and contexts beyond popular media, as well as additional guidance on understanding characters within the story worlds. The teacher recommended the inclusion of more classic works to replace some non-literary texts, which students found valuable for understanding global issues.

Overall, participants in the second workshop reported a positive learning experience. The tool was praised for helping students understand complex concepts through familiar contexts and for encouraging them to think critically about different perspectives. Recommendations for future workshops included incorporating more classic literature and providing better support for character context in story worlds.

IV. DISCUSSION

A. Potential of Works

ConceptualTales demonstrates the potential for fiction-inspired, AI-generated content for personalized education. Rhone et al. (2021) provide a framework for motivating student participation, emphasizing the importance of giving students ownership and inspiring them [3]. ConceptualTales embodies these principles by allowing students to select their favorite story worlds or add their own, thereby granting them creative freedom and autonomy. This autonomy fosters intrinsic motivation and engagement, aligning with the educational theories that stress the importance of student agency in learning [50]. Leveraging fiction-inspired content to enhance learning aligns with findings that narrative and imaginative contexts can significantly boost student engagement and understanding [54].

The interactive nature of the tool, including Socratic questioning, enhances critical thinking and deeper understanding [53]. The AI-driven personalization adapts to individual student interests, maintaining engagement and motivation [54]. Overall, ConceptualTales demonstrates significant potential in creating engaging, personalized educational experiences through fiction-inspired content and advanced AI.

B. Challenges

Despite its potential, there are several hurdles in deploying a narrative-based educational AI tool like ConceptualTales. One major issue is the inherent bias in popular story worlds, which are often male-dominated and white-dominated. This bias became evident when we created icons for each story world, typically looking to depict the main heroes or villains. Addressing this structural bias inherent in present-day media is crucial for promoting diversity and inclusiveness in educational content and promoting equity and diversity [55], [?].

Another challenge we encountered was copyright restrictions. Initially, we intended to use OpenAI's DALL-E [57] to generate images of characters from selected story worlds to enrich the learning experience. However, recent copyright regulations constrained the model's ability to depict specific characters or generate analogies that closely mirrored the original media. As a result, these images were either inaccurate or potentially misleading, prompting us to exclude them from the workshops. This issue highlights a broader challenge in the field of AI: balancing the creative use of AI-generated content with the legal frameworks that protect creators' intellectual property. As new regulations emerge, it is likely that these limitations will become more pronounced, necessitating careful consideration when integrating AI tools into educational settings.

VI. LIMITATIONS AND FUTURE DIRECTIONS

Our workshops had limitations, including relatively small participant pools with above-average proficiency in computer-based technologies. While running the workshops in different countries provided valuable insights, focusing on one country, such as the United States, could improve comparability by

examining diverse student groups within a single cultural context. The lower average ratings from Chinese students (7.7 vs. 9.5) might be due to the tool's design around American popular story worlds. Adapting the story worlds for international audiences could enhance relevance and engagement.

Future studies should incorporate control groups and additional variable groups to compare the effectiveness of ConceptualTales with other learning methods, such as using ChatGPT without the ConceptualTales interface, traditional books and search engines, and standard classroom materials. Additionally, the presence of app designers during playtests, even virtually via Zoom, may have influenced student feedback, potentially curtailing negative comments.

Ethical considerations regarding the student use of AI for schoolwork revolve around student privacy, the perpetuation of bias, and the erosion of student autonomy and resilience. The Institute for Ethical AI in Education points out that a student's "strengths, vulnerabilities, behavioral habits, and biometric information" could be leaked and/or misused in the educational space, with potential employers, or for commercial exploitation [58]. Data security "sandboxes" should be created to protect the surveillance of students' interactions with AI tools [59], [60]. In addition, if students develop an over-dependence on AI-based learning tools, their sense of agency, autonomy, and independent thought could atrophy while hindering learning [61].

Future implementations of ConceptualTales aim to enhance personalization and create more meaningful chat-bot responses. Ethical approaches to creating personalized story world backgrounds, illustrations, videos, and typography are essential. Accessibility should be addressed more thoroughly by incorporating colors readable to colorblind individuals and additional accessibility features for users with different needs, such as those using typewriters.

Based on student feedback, potential extensions could include story world characters providing thematic introductions to topics through animated interjections or role-playing as teachers to improve engagement. Pataranutaporn et al. [44] demonstrated that such interactions boost student engagement and learning outcomes [44]. Additionally, saving students' favorite story worlds on the server to avoid repeated manual input and integrating the chatbot more closely with classroom curricula can further enhance its usefulness.

Furthermore, we aim to enhance the responsiveness of our chat-bot by identifying and addressing potential user confusion. This could be accomplished through check-ins by story world characters (asking "Does this make sense to you?" in a gamified way). This will involve assessing student comprehension through interactive questioning of the material.

Finally, the formalization of professional development guides for this tool would increase teacher awareness and confidence in using ConceptualTales. These guides could include strategies for integrating the tool into daily lessons, examples of peer-to-peer learning activities centered around story worlds, and methods for incorporating the tool into homework assignments. Teachers could be trained on how to

facilitate small group discussions using the tool, leveraging its interactive features to promote collaborative learning. Additionally, providing case studies and best practices from early adopters could help educators visualize the tool's potential impact and effectively integrate it into their teaching practices.

By addressing these challenges and limitations, ConceptualTales can further its goal of making learning more engaging and effective through personalized, fiction-based analogies and advanced AI capabilities.

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APPENDIX

Appendix 1: System Prompt

You are a helpful assistant to help middle schoolers understand concepts. Explain the following concept and questions using analogies from the story world: [storyWorld]. If a story world is provided in the brackets, and is a valid story world,

use it, if not, use one useful story world from pop culture that middle schoolers would know. Progress in explaining complexities and depth as the conversation goes on. Please be concise (100-300 words) in your response so as to not repeat information. Please frequently end your response by asking a question to the user to check understanding. Respond using markdown.

Appendix 2: Most Popular Story Worlds

TABLE II

THE MOST POPULAR STORY WORLDS CHOSEN IN THE AMERICAN WORKSHOP WERE ATTACK ON TITAN AND FORTNITE. PARTICIPANTS IN THE WORKSHOP IN CHINA SELECTED STORY WORLDS FROM FILM AND ANIMÉ.

Story World	Mentions
Attack on Titan	2
Fortnite	2
Star Wars	2
League of Legends	2
Agents of S.H.I.E.L.D.	1
Animé	1
Kairotic Notes	1
Marvel	1
Mandalorian	1
Minecraft	1
Pokemon	1
X-Men	1

Appendix 3: User Prompts

TABLE III

FOLLOWING ARE A LIST OF SAMPLE USER PROMPTS AND SUBJECTS FROM THE AMERICAN WORKSHOP (WORKSHOP 1).

Topic	Subject Matter
Thematic Essay	Rhetoric
Discrimination	Rhetoric
Chemistry	Chemistry
Dipole-Dipole interactions	Chemistry
Chemical bonds	Chemistry
Chemistry - the whole subject	Chemistry
Balance chemical equations	Chemistry
History of Q-Pop	Kairotic Notes