

INTEGRATING LARGE LANGUAGE MODELS IN ART AND DESIGN EDUCATION

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ABSTRACT

This paper provides a possible strategy for integrating large language artificial intelligence models (LLMs) in supporting students' education in artistic or design activities. We outline the methodological foundations concerning the integration of CHATGPT LLM in the educational approach aimed at enhancing artistic conception and design ideation. We also present the knowledge and system architecture for integrating LLM in the °°Kobi system. Finally, this paper discusses some relevant aspects concerning the system's application in a real educational context and briefly reports its preliminary assessment.

KEYWORDS

Large Language Models, Art Education, Design Education, Creativity, Associative Thinking

1. INTRODUCTION

Artificial Intelligence (AI) has the potential to address some of the biggest challenges in education today, innovate teaching and learning practices. However, rapid technological developments inevitably bring multiple risks and challenges, which have so far outpaced policy debates and regulatory frameworks (UNESCO 2019). Generative AI models for natural language have created a new set of opportunities in the realm of creativity (Berns & Colton, 2020; Bown, 2012; Dwivedi et al., 2023; Hughes et al., 2021; Zhang et al., 2018).

Large language models (LLMs) are AI applications that are trained on enormous amounts of textual data. They are generative mathematical models of the statistical distribution of tokens found in the huge corpus of human-generated text, where tokens include words, graphemes, single letters and punctuation (Shanahan, 2023; Tunstall et al., 2022). LLMs such as BERT and GPT are becoming more common as a support in idea generation tasks due to their ease of use and strong generative capabilities, as they offer impressive abilities to answer questions, write perfectly contextualized or imaginative stories and even sustain a conversation (Raiyyan, 2023). The underlying technology is key to further innovation, and despite critical views and even restrictions in communities and regions, it is beyond dispute that LLMs will endure (Davenport & Mittal, 2022; Papp, 2023).

LLMs capabilities have both potential benefits and negative influences in educational applications from the perspective of students and teachers. There is no doubt that students' unstructured use of AI's generative capabilities through trivial copy-and-paste operations hinders the development of autonomous critical capacities. However, to the extent that generative capacities can be integrated within a well-defined didactic experience, they can serve as a tool for expanding imaginative capacities, thus amplifying the power of the creative practice. From the teachers' point of view, the rapidity of these technological advances and the increasing complexity of the pedagogical problems they raise call for reflection on the development of innovative solutions that can integrate these technologies into a well-funded pedagogical background (Alam, 2021; Liang et al., 2021).

In this article, we illustrate an initial attempt of integrating an LLM in the pedagogical framework for design and art education provided by the °°Kobi system, a knowledge-based system aimed at eliciting and sharing knowledge in communities of practice, and at fostering reflective and divergent thinking in creative processes (Giretti, 2022). We will illustrate preliminary experiences conducted in two design courses at the University of Florence, and a directing course at the Academy of Fine Arts in Rome, where the °°Kobi system, was introduced as an aid to collaborative ideation processes. On that basis, the article discusses the possibilities for the integration of LLM into the °°Kobi educational framework.

Section 2 will briefly describe the relevant educational context and the role of the °°Kobi system. Section 3 will offer a more abstract analysis of the knowledge cycle supported by the system, and Section 4 will discuss the integration of LLMs' language skills in that context. Section 5 will describe some preliminary experiments, and section 6 will discuss summarize the results and limitations briefly illustrate future developments.

2. THE °°KOBISYSTEM IN ART AND DESIGN EDUCATION

°°Kobi is a knowledge-based system aimed at fostering creative thinking throughout reflection, associative thinking, and multiculturalism as the key dimensions to be supported in creative education, to complement and enhance the apprenticeship practice. A thorough description of the °°Kobi framework can be found in (Giretti, 2022). The main °°Kobi features are:

- a) *Supporting reflective thinking* - by means of Knowledge Mapping interfaces that foster the creation of new critical and interpretative structures through abstract conceptualization and reflective observation, as well as reformulation and reinterpretation of contents (Wexler, 2001).
- b) *Supporting associative thinking* - by implementing large knowledge domains, arranged as shallow relational structures, encompassing multiple semantic contexts. °°Kobi uses both computational linguistics principles (Mitkov, 2022) and gestalt principles (Köhler, 1967) to establish semantic associations among texts or images belonging to the same or different semantic fields (Speer et al., 2017; Mednick, 1962).
- c) *Implementing the multicultural dimension* - by developing an ecosystem that integrates multidisciplinary contents based on well-defined semantics from the different disciplines and linguistic domains. °°Kobi generates what is commonly called a knowledge ecosystem (Szoniacky, 2018).

So far °°Kobi has been used as a collaborative design tool in two design methods courses at University of Florence and in one Direction course at the Fine art Academy of Rome. Different courses reflect the various teaching context, saying educational objectives, background knowledge, teaching styles, the cultural dimensions of the students, etc. Students and teachers used the Miro© frontend as a shared whiteboard to annotate their work in knowledge maps using different strategies, either following teachers' recommendations (e.g., brainstorming, the six hats method, the issue-concept-form) or in a free style (Figure 1 left). At present, the class has produced an ecosystem with more than 8,000 nodes representing a consistent core of shared knowledge to which the experiences produced by subsequent classes in the coming years will be added (Figure 1 right).

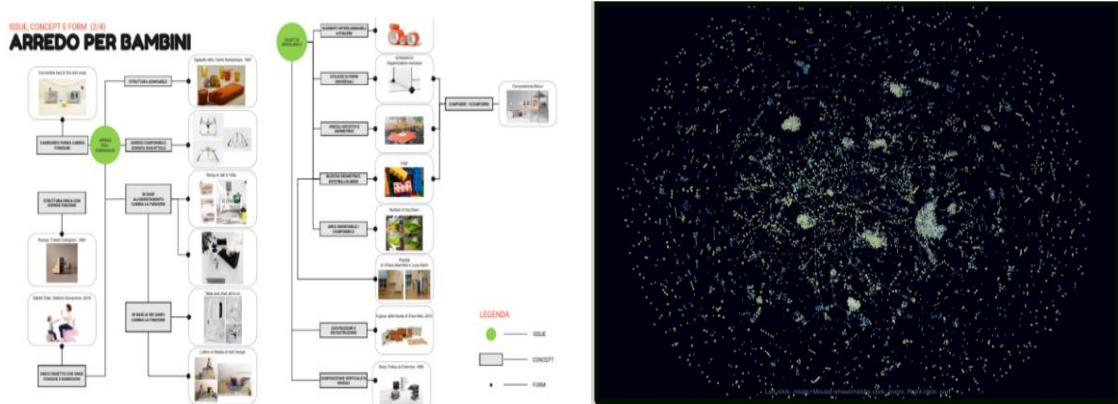


Figure 1. A student group's map (left) and the whole °°Kobi knowledge eco-system represented as a 3D graph (right)

In ^ooKobi, contents of different users are semantically related according to the principles discussed above, thus generating a knowledge eco-system that has multiple educational roles and relevance. First, each knowledge map naturally generates a linguistic domain or semantic field because it naturally reflects the terminology and the associations proper to the topic at hand. Syntactic associations between terms belonging to different linguistic domains tend to generate a polysemous or sometimes metaphorical shifts that are extremely relevant for creative thinking (Mednick, 1962). Our experience show that knowledge maps developed within a class share a rather well-defined semantic domain. We mean that the terminological field, the concepts, and their relationships are in great part shared among different student groups belonging to the same class. On the contrary, semantic relations that qualify shared words among different classes are significantly diverse (Figure 2).

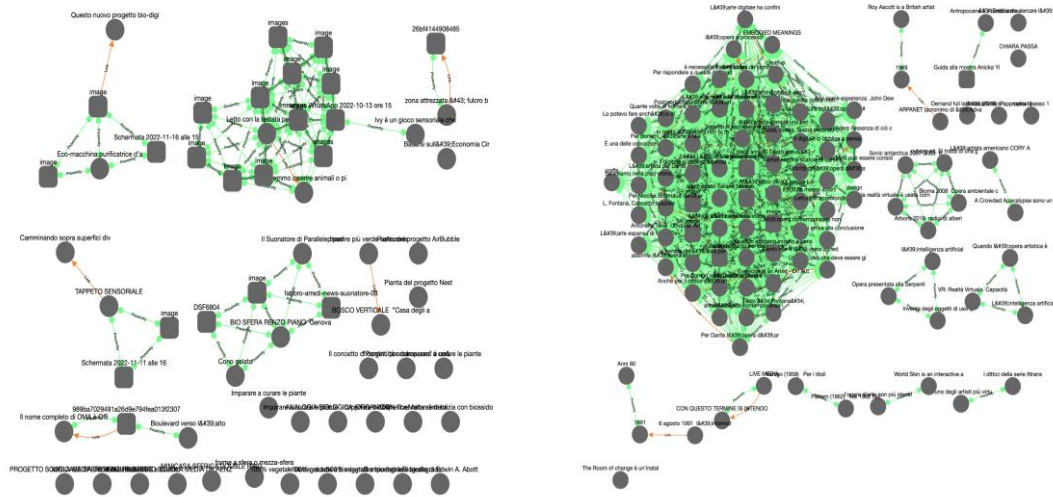


Figure 2. The semantic domain of the word ‘plane’ in a design class (left) and in a directing class (right)

3. THE KNOWLEDGE CYLCES IN THE ^ooKOBİ SYSTEM

^ooKobi can be used as a supporting tool in any experiential learning activity (Morris, 2020) seeking to emphasize reflective observation and abstract conceptualization within the concrete experience and the active experimentation of the atelier practice (Giretti, 2022). Knowledge is therefore the principal dimension of ^ooKobi and will be the main dimension of the LLM integration as well. Hence, to introduce the strategies for integrating LLM into ^ooKobi it is necessary to specify the main knowledge cycles that are supported by ^ooKobi in the educational contexts in which it is used. Figure 3 shows the main knowledge cycles of the ^ooKobi system.

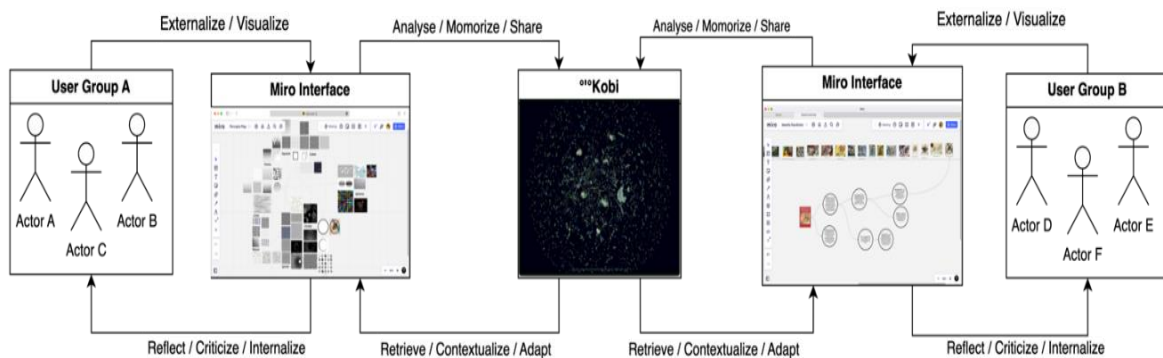


Figure 3. ^ooKobi main knowledge cycles – different user groups share their work through the ^ooKobi ecosystem

The first knowledge cycle (Externalize/Visualize) \Leftrightarrow (Reflect/Criticize/Internalize) is typical of a knowledge mapping system such as Miro© and has been extensively studied as a means of amplifying the learner's critical capabilities (Schön, 1983). The second cycle (Analyse/Memorize/Share) \Leftrightarrow (Retrieve/Contextualise/Adapt) can be traced back, if preferred, to a Case Based Reasoning protocol (CBR) (Kolodner, 2014). However, in °°Kobi it is conducted at the level of loosely structured, variable-grain knowledge fragments, rather than in well-structured fixed grain knowledge structures, as in CBR.

Retrieving contents from the web is indeed a diffuse practice among students of design and art courses to get inspiration for their work. The quality that distinguishes °°Kobi from a simple web search is the consistency of semantic context that is maintained during the search. A search in °°Kobi always produces a semantic context, similarly to what is shown in figure 2. Therefore, the fragments of knowledge provided to the student have an intrinsic semantic consistency and implicitly underlie a critical profile. Thus, the large volume of multimedia material available and its semantic arrangement produces a semantic focus that cannot be achieved with traditional web search engines. On the other hand, °°Kobi also supports divergent thinking by expanding the semantic context during research. In this way °°Kobi broadens the search domain by including semantic fields that are only terminologically related to the student's current focus, so that possibly divergent semantic structures are brought to attention. Again, this is a more sophisticated approach to divergent thinking than the naive divergence obtained as a side effect of the juxtaposition of disparate information in web searches.

4. EXPANDING THE REFLECTION CYCLE THROUGH LLM

The first (reflection) knowledge cycle in °°Kobi visually arranges project clues and its main contents. This cycle indirectly generates embryonic conceptual structures that are then analyzed and encoded in °°Kobi's knowledge base. °°Kobi primarily aim is, in fact, to capture the embryonic knowledge structures generated as a side effect of the reflection cycle. These structures generally lack linguistic coherency and a perfectly clear semantics. In other words, they are mostly unfinished because they are part of an on-going process. In that sense they are embryonic, because their relations are not perfectly qualified.

We believe that LLMs are a key technology in the exploration and in the qualification of these semantic structures. The impressive linguistic proficiency displayed by LLM systems underlies an equally large semantic base that is implicit in the huge sets of neural weights of their hidden layers. However, the LLMs implicit knowledge can be made explicit each time through well-defined dialogic interactions. Hence, the idea is that, if the interactions are based on the current semantic context the student is involved in, perfect synergies can be implemented by simply triggering the necessary generative or analytical processes in the LLM through appropriate questions. This is essentially what we have pursued.

The LLM has been used to implement two further AI based knowledge cycles in °°Kobi (Figure 4):

- *Expansion*: given a set of concepts, the process of expansion generates a paraphrase of the set of concepts. This paraphrase can be objective, that is, aimed at preserving as much as possible the initial conceptual context, or imaginative, that is, aimed at generating unlikely connections. Expansion uses the text generation function of LLMs.
 - *Conceptualization*: give an extended text, conceptualization lists and defines the concepts underlying the text. This function uses a complex mix of summarization capabilities of LLMs.
 - As mentioned, using LLMs with Text2Text generation function, the activation of both functions is solved by asking appropriate questions (Huggingface, 2023). Figure 4 shows how °°Kobi knowledge cycles have been enriched using LLM linguistic capabilities.
 - *Conceptualization* is used to make explicit the conceptualization of long texts (usually contained in pdf documents) so that each document can contribute to the associative exploration of the knowledge eco-system in a more consistent and rich way. In fact, each document is preprocessed and divided in paragraphs. Then each paragraph is conceptualized. The set of concepts are finally memorized in the knowledge eco-system and linked to the document.

- On the other side, *Expansion* is the process of enriching the associations of concepts that are encountered in an explorative step. Expanding a concept structure means asking the LLM to generate objective or fictional text and importing it as reflection material in the working space (i.e. Miro interface). This material then provides seeds for further steps.

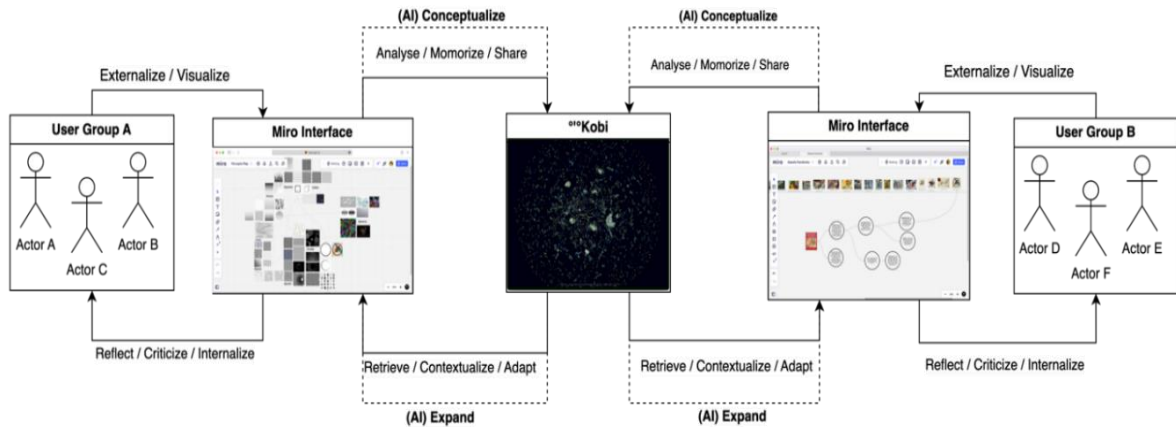


Figure 4. °°Kobi AI enriched knowledge cycle – AI provides conceptualization of long texts as well as explanation of concept clusters or ideation based on a well-defined semantic context

All in all, °°Kobi acts as a semantic broker between the students and the LLMs, with the goal of managing students' ideational journeys by exploring semantic pathways through structures of meaning that are retrieved, expanded or newly generated on demand during the creative process.

5. AN EXAMPLE

To corroborate what was discussed in the previous section, we will illustrate some exploration steps in the °°Kobi system using the knowledge base provided by the students in the courses.

Table 1 shows the transcript of the interaction between a student and the °°Kobi system that triggers the expansion and conceptualization processes based on the functionality of the LLM. The first step of interaction is through Kobi's search engine, which retrieves one or more semantic contexts, depending on the selected search scope. Figure 2 shows a graphical display of the two semantic contexts retrieved from the search using the word 'plane'. The student can expand the contexts retrieved by search engine using the LMM. In that case, the textual nodes of the contexts are pre-processed to obtain a set of tokens to be used for querying the LLM. The first step (right column in Table 1 first row) shows a subset of the generated tokens. The student then selects some tokens and uses a standardized question that triggers a textual expansion process (step 2 in table 1). The answer produced by the LLM consists of an articulated text that implicitly contains many new concepts. The student can then ask the LLM to succinctly enucleate the concepts in the text, again through a standard question form (step 3 in table 1). The answer, as shown in the right column, contains a much more explicit conceptual structure. Finally, the student can interact with the LLM in free form, asking for further insights (step 4 in table 1). The °°Kobi system tracks all interactions and, if requested, stores the exploratory path in its knowledge ecosystem.

Table 1. The transcript of a user interaction that engages AI functionalities and generates new conceptual structures

n	Step	Concept/Question	Answer
1	(°°) Search	plane	<ul style="list-style-type: none"> - Biosphere RENZO PIANO Genoa - Normal operation we need to move from the empirical plane - The Seattle Central Library - In the Jussieu Library, the technique used by OMA is based on horizontal rings - OMA reconfigures the typical layout of libraries by giving them new vertical surfaces - The sections of each floor are manipulated - The Jussieu Library - Embassy of the Netherlands - A city with urban elements - New urbanised public space - Vertical that are manipulated - Wood with upper levels - Connect with those above - Generative processes ...
2	(AI) Expand	Explore the relations among the following concepts: biosphere, generative processes and new urbanized public space.	<p>The biosphere, generative processes, and new urbanized public spaces are interconnected concepts that relate to environmental systems, societal development, and urban design. Here's an exploration of their relationships:</p> <ol style="list-style-type: none"> 1. Biosphere: The biosphere refers to the part of the Earth's surface and atmosphere where living organisms exist. It encompasses all ecosystems and includes interactions between organisms and their physical environment. The biosphere plays a crucial role in sustaining life on Earth, providing essential resources, regulating climate, and maintaining ecological balance. 2. Generative processes: Generative processes refer to the natural or human-driven mechanisms that create or generate something new. In the context of the biosphere, generative processes can include biological evolution, natural selection, ecological succession, and ecosystem dynamics. These processes drive the diversity and adaptation of organisms, shaping the functioning of ecosystems and the overall biosphere. 3. New urbanized public space: New urbanized public spaces are areas within urban environments that are specifically designed for public use and recreation. They can take various forms, such as parks, plazas, pedestrian zones, waterfront promenades, or green roofs. These spaces contribute to the quality of urban life, providing opportunities for social interaction, leisure activities, and access to nature. <p>Now, let's explore the relations among these concepts:</p> <ul style="list-style-type: none"> • Biosphere and generative processes: The biosphere is shaped by generative processes that operate on various scales and timeframes. Natural selection and evolutionary processes drive the adaptation and diversification of species within ecosystems. Ecological succession allows for the development and transformation of ecosystems over time. These generative processes are fundamental to the functioning and resilience of the biosphere, maintaining its biodiversity and ecological balance. • Generative processes and new urbanized public space: Generative processes can also be applied to the creation and development of new urbanized public spaces. Designers and urban planners use generative processes to shape these

			<p>spaces, considering factors such as community needs, environmental sustainability, and the integration of natural elements. By utilizing generative processes in the design process, new urbanized public spaces can be dynamic, adaptable, and responsive to the evolving needs of the urban environment and its inhabitants.</p> <ul style="list-style-type: none"> • Biosphere and new urbanized public space: New urbanized public spaces have the potential to contribute to the preservation and enhancement of the biosphere. Thoughtful design and management can integrate ecological principles and sustainable practices into these spaces. For example, incorporating green infrastructure, such as trees, green walls, or rain gardens, can provide ecosystem services like air purification, stormwater management, and wildlife habitat. Additionally, creating accessible green spaces in urban areas can help improve human well-being, promote physical and mental health, and foster a sense of connection to the natural world. <p>In summary, the biosphere, generative processes, and new urbanized public spaces are interconnected through their influence on ecological systems, societal development, and urban design. Understanding and considering these relationships can lead to the creation of sustainable, vibrant, and inclusive urban environments that support both human and environmental well-being.</p>
3	(AI) Conceptualize	Find the main concepts of the text above.	<p>The main concepts of the text above are:</p> <ol style="list-style-type: none"> 1. Biosphere 2. Generative processes 3. New urbanized public space
4	(AI) Expand	Can you suggest architects that used the above concepts as design clues?	<ol style="list-style-type: none"> 1. Ken Yeang: Ken Yeang is an architect known for his innovative approach to ecological design and bioclimatic architecture. His designs often incorporate principles of the biosphere by integrating greenery, natural ventilation, and energy-efficient strategies into buildings. Yeang's projects aim to create sustainable urban environments that harmonize with the natural ecosystem. 2. Stefano Boeri: Stefano Boeri is an Italian architect known for his work on vertical forests and urban reforestation. His projects, such as the Bosco Verticale in Milan and the Vertical Forest in Nanjing, China, integrate extensive greenery into high-rise buildings. Boeri's designs promote biodiversity, air purification, and the creation of new urban habitats, emphasizing the importance of the biosphere within urban contexts. 3. Bjarke Ingels: Bjarke Ingels is a Danish architect renowned for his innovative and sustainable approach to urban design. His firm, BIG (Bjarke Ingels Group), has developed projects that emphasize generative processes and adaptability. For example, the Amager Bakke waste-to-energy plant in Copenhagen incorporates a ski slope and a climbing wall, transforming a functional infrastructure into a dynamic public space that generates energy while offering recreational opportunities. 4. Jan Gehl: Jan Gehl is a Danish architect and urban planner known for his influential work on creating people-oriented, pedestrian-friendly urban spaces. His approach emphasizes the importance of designing cities for human scale, social interaction, and public life. Gehl's designs prioritize the creation of new urbanized public spaces that promote

		<p>walkability, connectivity, and livability, considering the needs and behaviors of people within the urban environment. These architects have explored and implemented innovative design approaches that align with the concepts of the biosphere, generative processes, and new urbanized public spaces, pushing the boundaries of sustainable and human-centric architecture.</p>
<p>5</p>	<p>(^o_o) Memorize / Share</p> <p><i>A new conceptual structure is generated in the Kobi knowledge ecosystem (solid lines)</i></p>	<p>The diagram illustrates a conceptual structure. On the left, a 'plane' node connects to 'generative processes', which in turn connects to 'biosphere' and 'new urbanized public space'. 'generative processes' also connects to a central 'text' block. The 'text' block contains two paragraphs: 1. 'Biosphere: The biosphere refers to the part of the Earth's surface and atmosphere where living organisms exist. It encompasses all ecosystems and includes interactions between organisms and their physical environment. The biosphere plays a crucial role in sustaining life on Earth, providing essential resources, regulating climate, and maintaining ecological balance.' 2. 'Generative processes: Generative processes refer to the natural or human-driven mechanisms that create or generate something new. In the context of the biosphere, generative processes can include biological...'. From the 'text' block, arrows labeled 'conceptualization' point to 'sustainability' and 'innovation experimentation'. From 'sustainability', an arrow labeled 'conceptualization' points to 'Community engagement and participation'. From 'Community engagement and participation', an arrow labeled 'expansion' points to 'Stefano Boeri'. From 'innovation experimentation', an arrow labeled 'expansion' points to 'Jan Gehl'. From 'Stefano Boeri', arrows labeled 'expansion' point to 'Ken Yeang' and 'Barke Ingels'. From 'Jan Gehl', an arrow labeled 'expansion' points to 'Barke Ingels'. Solid lines represent the primary structure, while dashed lines represent secondary or related concepts.</p>

Therefore in ^o_oKobi the students' interactions with the LLM occur within an exploratory path that has a well-defined semantic basis. The student is prompted to reflect on the conceptual structure underlying the possibly complex answer obtained from the LLM. Explaining this structure also allows such content to be stored within the knowledge ecosystem, becoming a primary object of the system, an object that will be able to interact according to the semantic principles of ^o_oKobi with all other materials produced and displayed in the interface.

6. CONCLUSIONS

^o_oKobi reinterprets the Knowledge Mapping paradigm (Wexler 2001) as the requirement of sharing the rich conceptualizations underlying the production of educational materials and students' homework, by indexing, storing, and retrieving them in a flexible and semantically rich manner. In this paper, we have discussed how the integration of Large Language Models (LLMs) in art and design education can be integrated to this purpose. We have outlined the methodological foundations concerning the integration of CHATGPT LLM in the educational approach aimed at enhancing artistic conception and design ideation and presented the knowledge and system architecture for integrating LLM in the Kobi system. We have also discussed some relevant aspects concerning the system's application in a real educational context and briefly reported its preliminary assessment. Using the LLM ability to create associations on a semantic level, ^o_oKobi improve the effectiveness of what is commonly called a knowledge ecosystem (Szoniacky 2018).

However, there are limitations to the research presented in this paper. First, the experiments were conducted in a limited number of laboratory tests at specific institutions, and therefore the results may not be generalizable to other educational contexts. Additionally, the experiments focused primarily on text-based ideation and did not explore the potential of LLMs in sound and image generation. Finally, the experiments have been limited to the knowledge generation and elicitation phases. In fact, during the tests, the system showed limitations in the usability of the interfaces. This would interfere in the evaluation of the entire knowledge cycle. Therefore, future work could include improving interface usability, extending the ^o_oKobi system to incorporate sound and image generation capabilities, as well as conducting experiments in a wider range of educational contexts to further explore the potential benefits and limitations of integrating LLMs in art and design education. Overall, the integration of LLMs in art and design education has the potential to revolutionize the creative process and enhance students' ability to generate innovative solutions to the most pressing problems of our time.

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