

KNOWLEDGE MAPPING FOR CREATIVE THINKING

Alberto Giretti¹, Massimo Lemma¹, Matteo Zambelli² and Franco Ripa di Meana³

¹*Università Politecnica delle Marche, Via Brecce Bianche, 60131 Ancona, Italy*

²*Università degli Studi di Firenze – Dipartimento di Architettura – DiDA, Via della Mattonaia, 8, 50121 Firenze, Italy*

³*Academy of Fine Arts, Via di Ripetta, 222 – 00186 Roma, Italy*

ABSTRACT

In this paper we illustrate the architecture of the °°Kobi system, which is aimed at supporting students' education in artistic or design activities. We will outline the scientific and methodological foundations of the educational approach aimed at enhancing the artistic conception and the design ideation. The functional requirements and the system architecture for implementing the °°Kobi system are outlined. Finally, the paper discusses some relevant aspects concerning the system application in a real educational context and briefly reports about its preliminary assessment.

KEYWORDS

Art Education, Design Education, Creativity, Associative Thinking

1. INTRODUCTION

Art education is a complex activity. Art involves an individual action of discovery, guided by the mutual action of mind and body, in which learning occurs as a creative act (Tanggaard 2014). Education in art is therefore an activity characterized by strong experiential and heuristic factors, which, in the growing of creative skills, take the form of inextricable combinations of ideas, forms and substance. In fact, learning in art triggers fundamental imaginative capacities, such as visualization, originality, invention, ordering, synthesizing and syncretizing, as well as empathy (Greene 1970). At the same time, art education is open to the entire history of cultural development, as it is aimed at the introjection and self-contamination of the cultural products that emerged in different historical periods and socio-cultural contexts (Addison 2010). The exposure to multiple cultures and/or multiple languages is beneficial for creativity (Lubart 2010). It enhances knowledge and challenges typical ways of thinking and acting. It leads people to overcome their cultural habits. Indeed, multicultural experiences foster openness to new ideas (Leung 2008).

Art education might benefit from learning environments that both provide opportunities and encourage students to think and behave creatively, and that ground their interpretative skills on a solid multicultural basis. How such environments should be arranged, their architecture and functional set-up is still an open problem (Glăveanu 2021). In this paper we illustrate the architecture of the °°Kobi system, a supporting system for the education of students involved in artistic or design activities that are characterized by a high creative factor.

In the actual pedagogical experience, art and design do work within or in relation to traditions, which are often technically demanding, requiring diligence, determination, immersion, and acculturation to and within valued conventions. Craftsmanship is one of the fundamental outcomes of such artistic learning, and apprenticeship is its usual pedagogical form. However, if creativity is the goal, there needs to be a balance between mastery of conventions, which provides satisfaction, confidence and self-esteem, and the visionary artistic tension, which makes it possible to break established rules and develop new expressive means (Csikszentmihalyi 1996). (Kolb & Kolb 2017) analyze to a full extend the experiential nature of apprenticeship pedagogy. Experiential learning models suggest the idea that learning is by nature a process full of tension and conflict, where the moment of learning is co-articulated with the moment of doing. New knowledge, skills or attitudes are achieved through the confrontation among four different types of skills:

- a) *concrete experience skills* - learners must be able to involve themselves fully, openly and without prejudice in new experiences,

- b) *reflective observation skills* - learners must be able to reflect and observe their experiences from many perspectives,
- c) *abstract conceptualization skills* - learners must be able to create concepts that integrate their observations into culturally relevant theories,
- d) *active experimentation skills* - learners must be able to use these theories to make decisions and progress the artwork.

Experiential learning therefore requires skills that are inherently opposites. So, there are two primary dimensions in which the learning process can be developed along:

1. The first dimension represents concrete experience of events at one extreme and abstract conceptualization at the other.
2. The other dimension has active experimentation at one extreme and reflective observation at the other.

In the experiential learning process, the learner moves in various degrees from actor to observer, and from specific involvement to general analytical detachment (Morris 2020). In this scenario, °°Kobi is a complementary tool to the apprenticeship of techniques and operational practice, seeking to emphasize reflective observation and abstract conceptualization (figure 1).

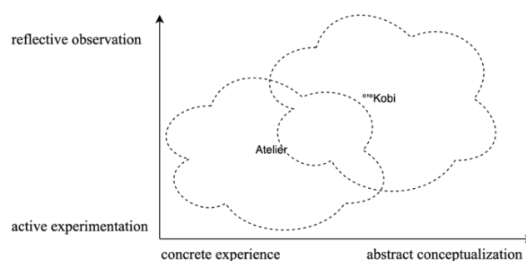


Figure 1. Experiential learning dimensions

In sections 2 and 3 we will develop in detail the operational implications of this methodological vision, the essential features of the system architecture and interfaces, and in section 4 we give some examples of use in real classes of students. In the conclusion section we will outline the current implementation limits and the future research work.

2. THE °°KOBİ APPROACH

°°Kobi is a knowledge-based system aimed at fostering creative thinking throughout the educational process of art and design academies, with the aim of realizing a multi-cultural eco-system for creative learning, well-grounded on an operationally sound cognitive theory of creativity. The previous section pointed out reflection, associative thinking, and multiculturalism as the key dimensions to be supported in creative education, to complement and enhance the apprenticeship practice. On that basis the following functional requirements for the °°Kobi system has been defined:

- a) *Supporting reflective thinking* - by means of 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.
- b) *Supporting associative thinking* - by implementing large knowledge domains, arranged as shallow relational structures, encompassing multiple semantic contexts.
- 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.

2.1 Knowledge Mapping

°°Kobi reinterprets the Knowledge Mapping paradigm already widely used in the domain of Knowledge Management (Wexler 2001). The Knowledge Mapping objective of capitalizing on corporate knowledge is translated to 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. Hence, °°Kobi supports the development of a large multicultural knowledge base by collecting the conceptual work of teachers' and students' communities. Knowledge in °°Kobi is organized in maps (Figure 2). According to (Novak 2009), knowledge maps improve meaningful learning, associative and reflective thinking since users are "obliged" to represent their knowledge in a structured and relational fashion. (Davis 2011) shows that the externalization of knowledge structures on maps fosters self-reflection and enhance critical thinking as well. In °°Kobi each map has a well-defined scope that is considered as a specific *semantic field* (Lyons, 1977), In that way °°Kobi introduces a first level of semantic structure.

2.2 Associative Thinking

°°Kobi knowledge representation schemata are limited to associative knowledge structures. °°Kobi provides no formal means of defining knowledge structures to support any form of automated reasoning except associative chains. The knowledge depicted on the maps' canvas as graph structures explicitly outlines the basic form of associative arrangement. Other features are used to identify further degrees of association among the knowledge elements represented in the canvas. The first, obviously, concerns the linguistic content of texts. Computational linguistics (Mitkov 2004) allows the use of very flexible terminological associations, possibly using specific corpora (Speer et. al. 2017), to establish semantic associations between pieces of text belonging to the same or different *semantic fields*. The spatial layout of contents offers a third possibility to infer implicit associations. According to the gestalt principle of *proximity* (Köhler 1967), objects or shapes that are close to one another appear to form groups, hence they are tententially considered semantically more relevant than elements that are far away from each other. Hence *proximity* is used in °°Kobi as a further principle of semantic association. *Proximity* is a principle that has great practical value. In fact, it allows any content to be associated regardless of its nature. Thus, through proximity it is possible to associate text with text, but also text with images and images with images or any other type of media content (video, sound, etc.). By combining *proximity*, maps' wired links and linguistic associations °°Kobi realizes a rich mean of navigation by association (Figure 2).

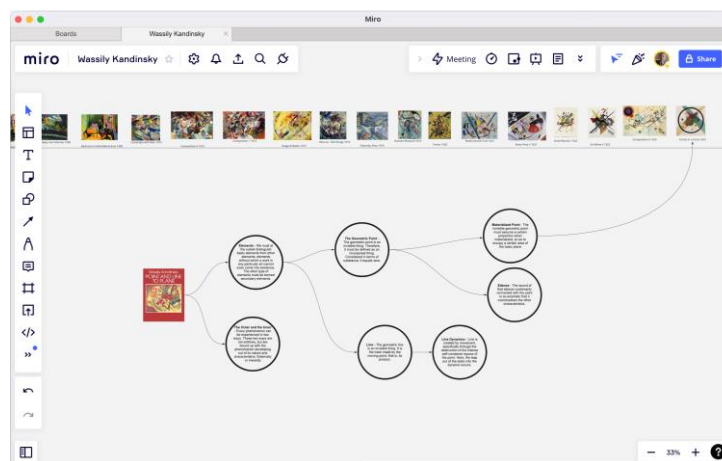


Figure 2. A fragment of an essay map freely drawn by a teacher with different styles. The map represents a semantic context. Proximity (top image line) and explicit links (bottom part) has been used as associative means

2.3 The Knowledge Ecosystem

The cultural component of creative thinking is supported in $\circ\circ$ Kobi through technologies for collaborative work. These technologies enable the creation of communities of users, whether teachers or learners, who share information, documents, or media material, interact and communicate with varying degrees of flexibility. Using the ability to create associations on a semantic level, $\circ\circ$ Kobi generates what is commonly called a *knowledge ecosystem* (Szoniacky 2018). In $\circ\circ$ Kobi, contents of different users are semantically related according to the techniques discussed above, thus generating a universe of knowledge. Such a universe has multiple educational roles and relevance. First, each knowledge map naturally generates a linguistic domain or semantic field by adopting a terminology and structuring associations proper to the topic at hand. Syntactic associations between terms belonging to different linguistic fields tend to generate a polysemous or sometimes metaphorical shift that is extremely relevant for creative thinking (Mednick 1962). On the iconographic level, the proximity association of terms and images on different semantic fields creates very rich contexts for the creative interpretation of visual and/or conceptual suggestions. Finally, $\circ\circ$ Kobi makes it possible to navigate the associative fabric thus created, generating interpretative paths that may diverge (Runco 2012) while remaining within a set of well delineated and relevant semantic fields. This lets $\circ\circ$ Kobi be in clear complementarity with, for example, traditional search engines that do not allow searching by semantic relevance. In fact, $\circ\circ$ Kobi allows one's own linguistic scopes, generated during associative navigation, to be used as a pool of search keys for traditional search engines (see section 4.2).

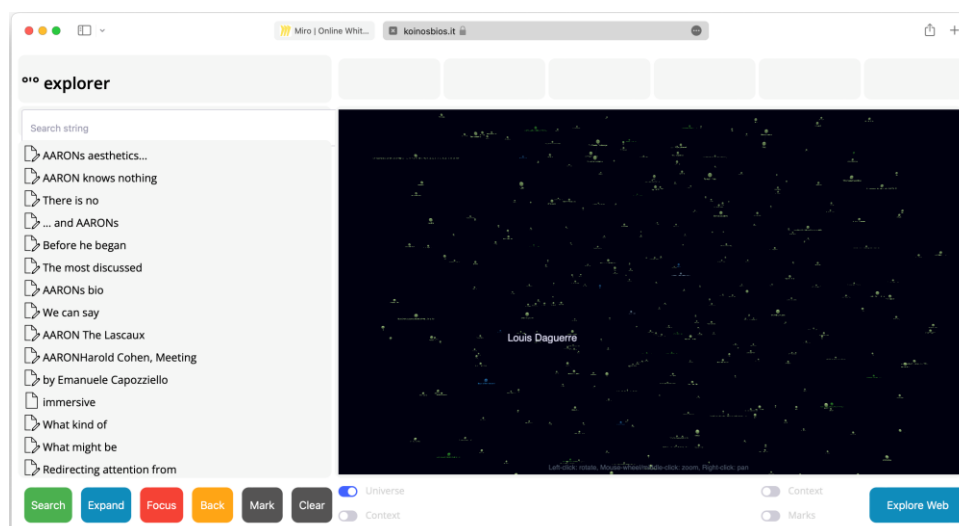


Figure 3. $\circ\circ$ Kobi knowledge eco-system represented as a content list (left) and 3D graph (right)

3. $\circ\circ$ KOBI ARCHITECTURE

$\circ\circ$ Kobi was developed as a web environment by selecting from the pool of current methodologies and available technologies what maximizes usability and dissemination in learner communities. Being a web-based application $\circ\circ$ Kobi consists of a front-end that implements the user interface and a back-end that implements the business logic services and knowledgebase functions. GUI quality and usability was considered a key factor for the successful development of application. Hence the Miro© platform¹, a commercial knowledge mapping tool, has been used. Miro offers state-of-the-art usability, flexibility, and support for collaborative work. It is also open to the development of custom applications and, with some limitations, totally free for academic and educational purposes. A large part of $\circ\circ$ Kobi's front-end has thus been developed as a Miro application. Hence, Kobi uses the Miro boards as its main knowledge mapping

¹ <https://www.miro.com>

tool. The Miro app interoperate with the °°Kobi server to provide autonomous navigation in the °°Kobi knowledge ecosystem. The °°Kobi's back end has been implemented in Node.js. The database uses a graph DB technology, by means of the open source Neo4j application, which maps very well with the knowledge representation requirements of the °°Kobi application.

4. USING °°KOBİ

The overall °°Kobi's usage profile in the educational context is twofold. On the one hand, °°Kobi can be used as a knowledge elicitation tool during the authoring teaching material by lecturers. In this case °°Kobi can be used both to create the conceptual brochures that will be the basis for the development of the final material, and/or to create the final form of the content to be used in the classroom lessons. On the other hand, °°Kobi can be used by students as a tool to support the development of group work assigned during courses. In both cases, °°Kobi is a tool for capitalizing on the knowledge produced as it allows a substantial amount of learning material to be accumulated and retrieved with a good degree of semantic coherence.

4.1 Authoring in °°Kobi

The production of learning material represents one of the main educational activities in Higher Education. This primary activity usually takes place by progressive refinements of conceptual schemes that are then enriched with explanatory material. This process can be effectively supported by a knowledge mapping tool. The use of °°Kobi allows teachers to capitalize on the knowledge produced by sharing it in a *knowledge ecosystem*. Shared knowledge is semantically related to the contributions of colleagues from other disciplines. An example of °°Kobi authoring is shown in figure 2. It illustrates a fragment of an essay written by a teacher concerning a lesson about the painter Wassily Kandinsky. The simple organization principles of °°Kobi's maps allow the implementation of association structures with different semantic valences. For example, the top line of images ordered in temporal succession and annotated with milestones provides associative chains based on the timeline principle. Conversely, the inclusion in the bottom area of a painter's essay, which excerpts are explicitly annotated and commented, implements a knowledge structure with critical valence.

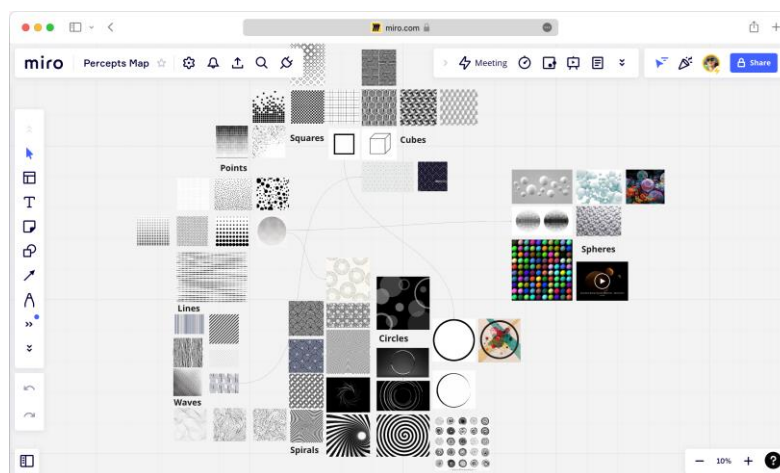


Figure 4. An example of a perceptive map

The two perspectives are then explicitly related through links connecting concepts and paintings, thus creating a rich interpretative framework that can be retrieved and used by students during their homework development. A second example concerns a knowledge map aimed at fostering the learners' imaginative and visual thinking skill. Figure 4 shows a map that organizes iconographic and media materials around primary graphic concepts such as point, line, square, etc. The structure of the map relates the primary concept expressed as text with different iconic materials produced by designers and artists. The associations are

nanced, proceeding by proximity or by explicit connection. In the composition of a map, it is therefore possible to define a gradualness, or, if we want, a degree of association, of an image to a concept, as well as a transition chain from one concept to another through hybrid images, which possess traits of both.

4.2 Navigating ^{oo}Kobi's Associative Chains

The main use of ^{oo}Kobi as a teaching tool is to support the construction of conceptual structures that have significant semantic relevance in their own cultural contexts. To this aim ^{oo}Kobi provides navigation tools in the knowledge ecosystem that allow on the one hand a free navigation by semantic associations on multidisciplinary domains, and on the other hand the collection of a well-founded linguistic and terminological background that potentially improves the semantic focus of traditional search engines. We will see some examples in the remainder of this section, using for clarity the limited set of maps introduced so far. We start by trying to investigate about the concept of *Point*. This can be done by inserting the concept as a textual element in the map and asking ^{oo}Kobi to expand the concept (i.e. to search about it in the ecosystem) (Figure 5 – left). The result consists of texts and images that are directly related to the *Point* concept in different maps (Figure 5 – right).

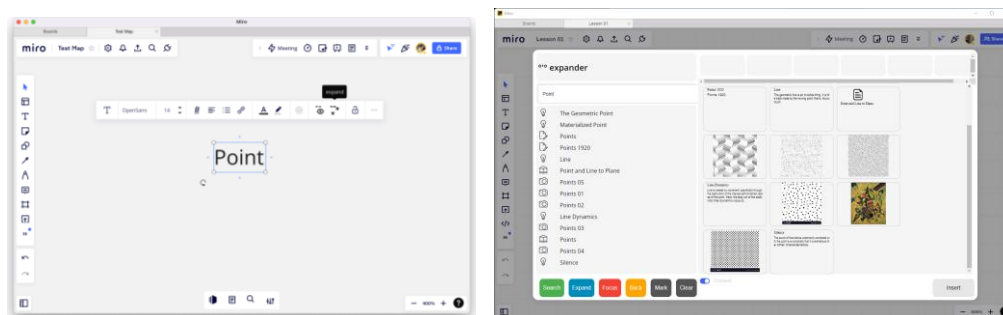


Figure 5. Investigating the Point concept - Stating the concept (left), first expansion in the knowledge base (right)

Notice how the conceptual richness of the knowledge ecosystem is reflected in the results. The multimedia elements have been recovered by proximity in different contexts belonging to different semantic fields. Some of them, like the texture images, are purely perceptual, others belong to well-structured critical essay, like the paint image, others are textual elements that are linguistically related to the key concept. Each of these results can be further investigated in detail (Figure 6 - left) and either pinpointed in the top boxes or inserted into the map and linked to the original text.

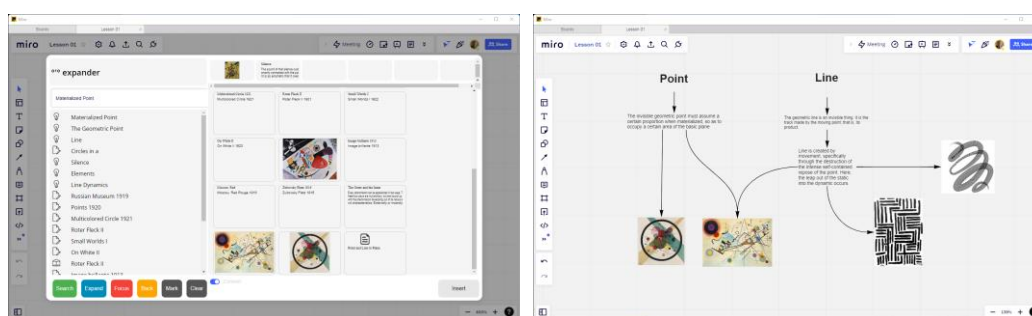


Figure 6. Investigating the *Point* concept - Second expansion (left), final arrangement (right)

In this way, the students can build a rich representation of the *Point* concept, drawing on semantically well-focused teaching material producing their interpretations and new meanings with a significant cultural and inventive involvement (Figure 6 - right).

A similar approach can be used to mitigate the typical generality of traditional Web search engines. In this case, a preliminary search operated on the °°Kobi ecosystem allows the student to define a rather focused linguistic context, which can then be used as a set of search keys in commercial Web search engines. Very often this leads to more semantically targeted search results.

4.3 °°Kobi in a Design Classroom

°°Kobi was used to support a design methods course, whose title is “Methods for construction quality”, in an undergraduate curriculum at the Department of Architecture of the University of Florence (Italy). The class consisted of forty students who worked arranged in groups in on-line sessions using the collaborative work support offered by the °°Kobi platform. Each group had to design a product in relation to a theme assigned by the lecturer and reflect their design process on a °°Kobi board through a well-defined set of conceptual design methods, including brainstorming, the six hats method, the issue-concept-form formalism, heuristics such as analogy and metaphor. Students must build a map related to each conceptual design methods. All the maps were discussed with the lectures and shared with the other students, who could suggest their colleagues how to improve the maps. At present, the class has produced an ecosystem with more than 1,000 nodes representing an initial core of shared knowledge to which the experiences produced by subsequent classes in the coming years will be added. In this way °°Kobi support the capitalization of class experience. Obviously, the knowledge produced by students reflects their degree of critical insight, and thus tends to be less semantically structured than what can be produced by a professor in a specific essay. However, the sheer volume of multimedia material produced and its organization by themes and simple keys produces a semantic focus that, even at this level, cannot be achieved with traditional search engines. Figure 7 shows an example of students’ boards.

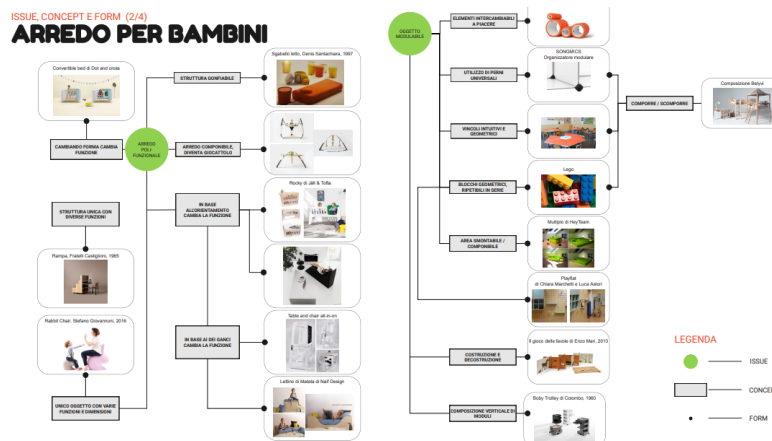


Figure 7. Fragments of an issue-concept-form board developed by groups of students in a design method course at Florence University in Italy. Text is in Italian

The students' experience of using such tools in teaching was in their opinion positive, according to what they expressed in informal interviews during the course, as was the teachers' assessment of the practical effectiveness and quality of the final work.

5. CONCLUSIONS

In this article we discussed the main features of the °°Kobi system for supporting creative learning. Areas of application of the system in the context of current educational practices for teaching in fine arts and design curricula were highlighted, and its functional peculiarities that enable it to support students' construction of critical knowledge were highlighted. °°Kobi is currently in an early stage of development, where the focus is on usability and robustness of the tools used within traditional educational settings. Therefore, the system has many limitations in content processing and structuring. Linguistic processing is currently limited to lexical

analysis only. Algorithms for using *Wordnet synsets*, for example, have not yet been implemented. Nor has the interface to external content repositories such as, for example, *Europeana* and *Getty images* been developed. At present, as mentioned in the preceding paragraphs, no form of structured knowledge expressed through labeled relations is supported, such as, for example, the *issue-concept-form* or *six-hats* paradigms like in Figure 7. However, despite these limitations, initial results have shown good operation of the tool in the context of a product design class for an undergraduate course in a higher education curriculum, and teachers' preliminary evaluations of student work, including in relation to the development of a critical apparatus of final papers, are positive. However, in order to have a more objective and comparable assessment of the effectiveness of the method, it will be necessary in future research to evaluate the system within a protocol that has a solid pedagogical basis.

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