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Definitions, Taxonomies and Functions of Visual Thinking as an Educational Ecosystem: A Scoping Review †

Maria Vittoria Battaglia * and Francesco Maria Melchiori

Department of Economic, Psychological, Communication, Educational, and Motor Sciences, Niccolo Cusano University, Via Don Carlo Gnocchi, 00166 Rome, Italy; francesco.melchiori@unicusano.it
* Correspondence: battagliamariavittoria@gmail.com

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Abstract

The scoping review examines how pedagogy can incorporate visual language and imagination as integral components of the learning process. Sixty-four studies were analysed following PRISMA-like guidelines to identify definitions, taxonomies, pedagogical functions and skills required by visual thinking. The results highlight the cognitive, communicative and motivational role of visual tools and the active contribution of students in the construction of meaning through images. The study proposes an integrated definition of visualisation as an analytical, generative and socially situated process of meaning creation through visual and symbolic forms, offering a conceptual basis for the development of multimodal and creative educational practices.

Keywords: visualisation; imagination; representation; visual literacy; visual learning

1. Introduction

The contemporary world is characterised by a predominantly iconic mode of communication, which defines the cultural and cognitive environment in which students are immersed. This growing visual culture calls for a pedagogical reflection on the role of visual language and imagination in teaching–learning processes. However, addressing this issue is complex because there is a lack of categorical clarity regarding the topic and its declinations. In the literature, among the terms that most commonly emerge in relation to the visuospatial sphere, we find imagination, representation, and visualisation, which refer both to the content and to the modalities of representation [1]. Those are often used either to explicate different constructs or as synonyms that imply a degree of isomorphism or analogy—structural, conceptual, physical—or symbolism between the representative and the represented. This leads to understanding imagination as a category that encompasses whatever implies a simulation [2,3] or a substitution [4]. However, central questions remain open: is representation a means or an object of learning? An active process of meaning construction or a passive process of information acquisition? The scoping review presented here aims to address these questions. It is framed within the cognitivist paradigm, with particular reference to Paivio's Dual Coding Theory [5] and Johnson-Laird's Theory of Mental Models [6]. Both conceive of imagination and representation as internal cognitive processes that allow visual and verbal information to be processed, integrated, and manipulated. These frameworks are integrated with socio-semiotic perspectives on visual literacy [7], which emphasise the cultural and communicative dimension of representations.

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This theoretical integration enables us to view imagination as both a cognitive process and a social practice of meaning construction.

The aim is to answer the following research questions:

- Question 1: What is meant by visualisation within the educational context?
- Question 2: What are the educational functions and skills required for the use of visual media in education?

Beyond mapping existing definitions and taxonomies, this review contributes by integrating cognitive, semiotic and pedagogical perspectives into a unified conceptual framework of visual thinking, thus proposing an ecosystemic reading of representations that links definitions, formats, functions and skills.

2. Research Strategy

The research was conducted according to the methodological criteria of a scoping review [8].

The search was conducted on ERIC and EBSCO for the primary sources, and Science Direct, Frontiers in Education, Springer Open, and Google Scholar for the search of the references. The following string was used: abstract:(imag* OR visual* OR picture OR illustration OR representation) AND abstract:(learn*) AND abstract:(student OR pedagog*).

The search was filtered to include only results in Italian or English and subjected to peer review. It was decided not to delimit the time frame in advance, to be able to explore the relevant literature available in any period and trace the evolution of the definitions and interpretations of the concepts analysed.

As far as the type of paper is concerned, it was decided to include both theoretical and experimental research in the initial search.

The initial search provided 942 articles (358 on ERIC and 584 on EBSCO), from which three duplicates were removed and to which 32 articles were added, which were identified among the bibliographic references. Two researchers (including the doctoral student who authored the article) independently reviewed the titles and abstracts. In case of disagreement, a third reviewer (the professor who supervised the work, co-author of the article) intervened for the final decision.

The selection process included exclusion criteria relating to the following:

- empirical studies without a theoretical component;
- non-educational contexts;
- publications not in English or Italian.

At the end of the study selection process, 64 articles were identified (Figure 1).

The selection and exclusion of items have been done without the use of software.

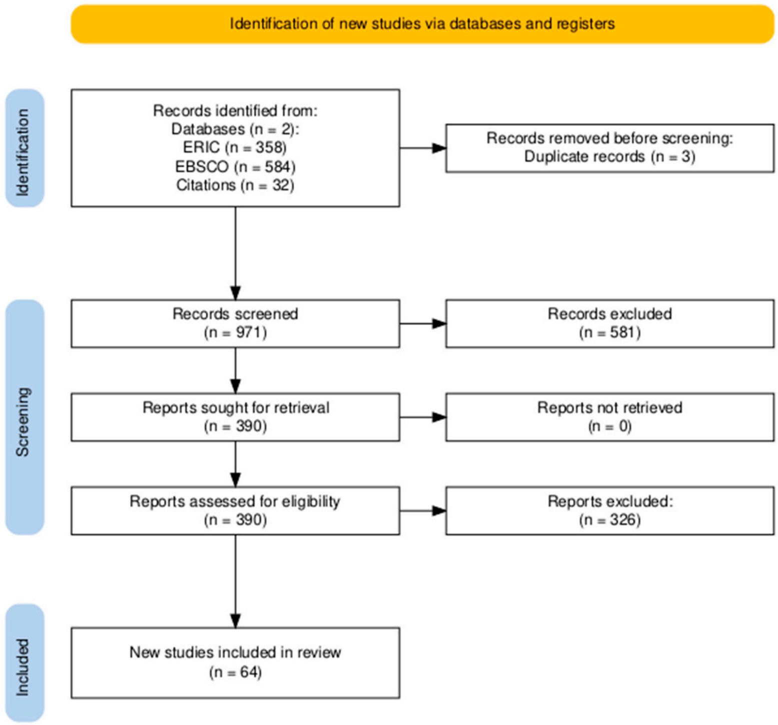

Figure 1. Prism chart of article selection [9].

3. Results

The themes that emerged from the articles analysed were organised into the following four interconnected macro-themes:

- Definitions (what is representation);
- Types of representations (how is the representation);
- Pedagogical functions of images (what it is for);
- Representational skills required to interact with it (what you need to be able to do).

These dimensions are dynamically intertwined and contribute to defining the sphere of the visual in education as a dynamic ecosystem of cognitive processes, semiotic tools and teaching practices.

3.1. Definitions

Among the recurring definitions we can identify the following three main conceptual axes: imagination, understood as mental reproduction, a generative activity that leads to the construction of mental models [10]; representation, which indicates an object that stands for something else [3,11]; and visualisation, which indicates the act of making a content or a concept visible, both in internal (imagining) and external (drawing, modelling) form [1,12]. Closely related to this concept is that of visual learning, defined as the ability to organise, structure and assign meaning to visible objects to assimilate new information.

These concepts are considered interdependent: imagination generates representations, visualisation concretises them, and representation constitutes the shared cognitive and semiotic unit. Arcavi [13] provides a definition of visualisation that becomes an umbrella term to summarise the various definitions reported in this paragraph, understanding it as "the ability, the process and the product of creation, interpretation, use of and reflection upon pictures, images, diagrams, in our minds, on paper or with technological tools, with the purpose of depicting and communicating information, thinking about and developing previously unknown ideas and advancing understanding" [13].

3.2. Types of Representations

Representations can be distinguished by place, i.e., internal—images and mental models [14]—or external [3,12], dynamism—static, which fixes a state, or dynamic, which show processes and transformations but require greater cognitive load [15–17], and degree of abstraction—concrete or abstract [18], physical, virtual or blended [17]—which influences the student's ability to map the disciplinary content. Representations can also be classified according to their dimensionality [3], the format, the sensory channels used, the semiotic mode, and the type of information conveyed (qualitative or quantitative). The way in which they relate to the referent is a categorising criterion too, i.e., whether they maintain a relationship of direct or indirect, analogical physical similarity (isomorphism) with the object represented, or simply an arbitrary, logical relationship [4,19,20]. This multidimensional taxonomy shows that there is no "best" representation, but rather contextual teaching choices that must take into account objectives, content and student profiles. It is important to recognise that each type of representation activates different cognitive mechanisms—from perceptual to logical-procedural ones.

A summary of all the types of representations that emerged in the revision is shown in Figure 2.

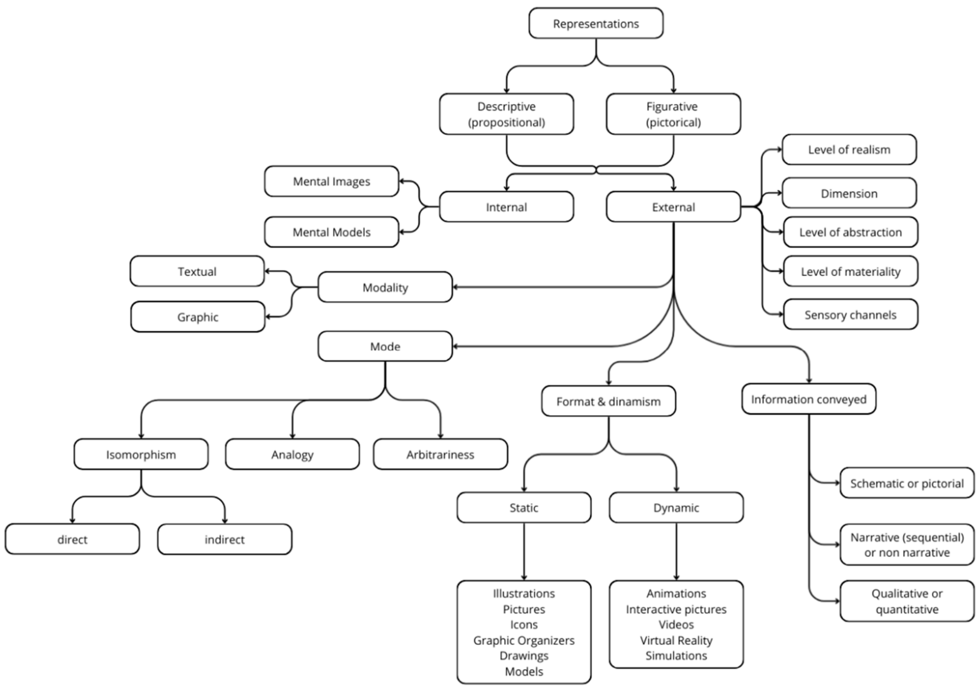

Figure 2. Integrative scheme of all the distinctions between the various types of images that emerged from the revision.

3.3. Functions

The third thematic area identified in this revision is that of the functions of images in the educational field (Figure 3).

Clark and Lyons [15] recognise two classes of functions, psychological and communicative, i.e., decorative, representative, transformative, organisational, interpretive, mnemonic, and relational [15,21]. Psychological functions, on the other hand, concern attention support, knowledge activation, minimisation of cognitive load, facilitation of mental model construction, support for knowledge transfer, and motivation support. These functions appear to expand on the theories of Ainsworth [22,23], which recognise the functions of adding new information (complement), preventing possible misinterpretations (constrain), and leading to the construction of new knowledge (construct), thereby decreasing the cognitive effort required (computational offloading).

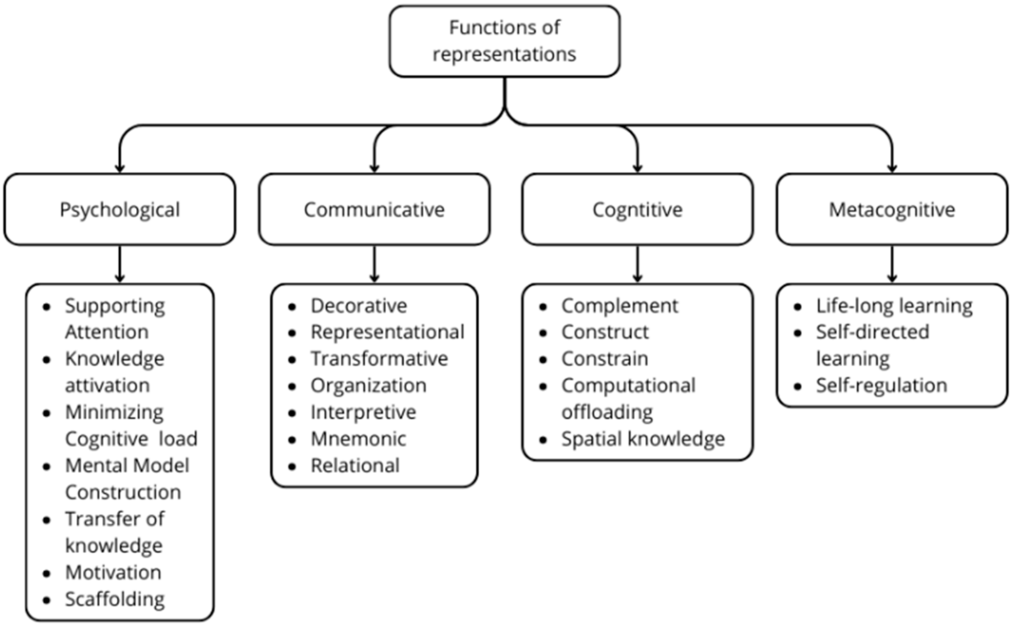

Figure 3. Summary of the functions of the representations for learning found in the literature.

There are the following two main purposes in the use of representations, especially if produced by the students themselves, in the educational field: an active purpose, which implies the activation of previous knowledge [10], the memorization and integration of new information; a constructive purpose, as in producing an image the student does not limit himself to externalising what he thinks but changes it, giving meaning to abstract and complex contents [13]. They therefore perform a scaffolding function, supporting generative learning and student self-regulation, encouraging them to engage in metacognitive processes and reflect on their understanding of the content [24,25].

3.4. Representational Skills

Students need representational skills that allow them to create meaning from the information shown by visual representations (sense-making) [23] and to perceive the disciplinary content conveyed through them (perceptual fluency) [26]. To give meaning to the visual information present in representations, it is necessary to organise and integrate this information with what is already known [10,15]. Representational skills are defined as visual literacy [7] (Figure 3), i.e., the set of abilities that allow one to understand, interpret [1,27] and create [28] messages of a visual nature.

These skills can be summarised in the following four interconnected macro-areas [7,29]:

Visual reading (perceptive and interpretative ability to read and internalise visual meanings), visual writing (productive competence to create and make visible ideas and concepts), visual thinking (organisation and mental structuring of information), and visual learning (integration and selection of visual information to build knowledge).

Transversal is the translation competence between different codes and different formats (mapping correspondence). These dimensions outline a transversal repertoire of skills that allows us to move from consumption to conscious production of images [29,30].

Figure 4 summarises and integrates such abilities into a coherent definition.

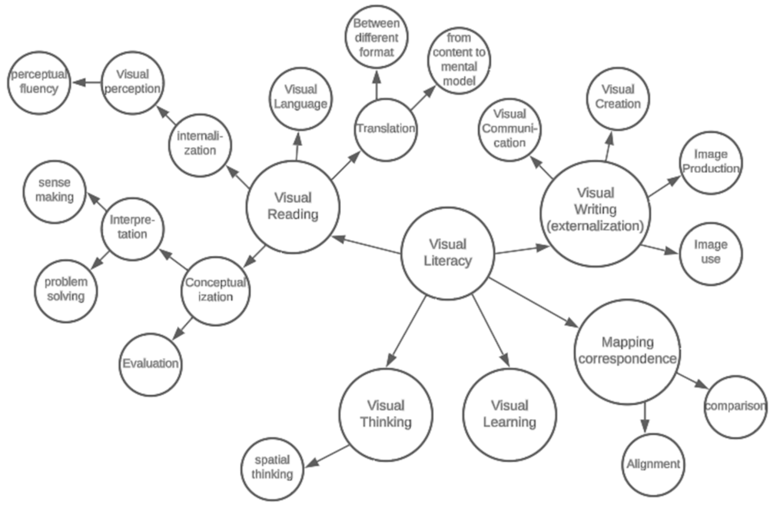

Figure 4. Summary of the representational skills that emerged from the literature.

4. Conclusions

The review analysed the literature to clarify the definitions of imagination, representation and visualisation in the pedagogical field, tracing them back to the broader category of visual thinking, defined as an active and analytical process of interpretation and construction of meaning through internal or external visual forms, which allows to represent, explore and communicate ideas. It integrates the following three complementary dimensions: simulation, linked to the mental activity of the imagination; semiotics, relating to languages and visual conventions; and teaching, as a practice of mediation and co-construction of knowledge. In this perspective, imagining, representing, and visualising are aspects of a single macro-area of visual processing, which links perceptual experience, representation and mental image. Therefore, the use of visual media in education involves not only seeing, but also creating and reflecting. This suggests some operational guidelines, such as the need to align the choice of visual materials with the communicative and psychological functions of the task, to explicitly teach how to read and construct representations, to promote student-generated visualisations as generative learning and self-regulation tools, and to use graphic organisers as externalised mental models, capable of fostering metacognitive reflection.

The methodological limitation of the revision—linked to linguistic selection, the absence of empirical studies—requires further experimental validation to translate this theoretical evidence into applicable educational models.

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