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# Composition of Engineering Drawing through Communication Skills and Social/Material Interactions from the Semiotic Aspect

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**Abstract.** The report analyses how to better proceed from general discussion on graphic literacy in engineering education, through communication between the triad components: concept (problem, engineering idea, existing object), teacher and student, from the semiotic point of view, using Peirce's triadic model whose the basic claim is that signs consist of three inter-related parts: object, interpretant and represent. A pedagogical model is presented in the form of a triad, where problem solving is focused on form: object-problem identification or existing product; interpretant-teacher and interpretant-student who form teacher concept (TC) and teacher representation (TR), and student concept (SC) and student representation, i.e. engineering drawing (SD). At all stages of the learning process the teacher must rely on interpreting students' representations as the evidence of their understanding. Successful application of representational images (engineering drawings) is not a simple task; it is something that must be trained and used in professional practice, as manufacturing of real products is based on engineering drawings.

## 1. Introduction

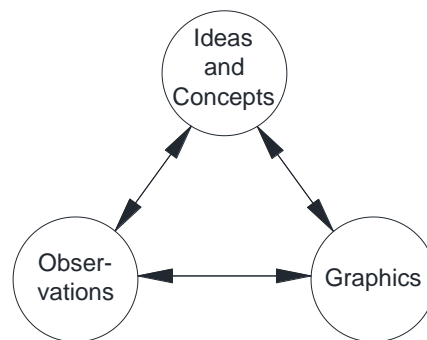
In the long history of visualization in engineering graphics, one has gained (presented) new ideas for solving problems [1]. Because in ancient times drawing was not considered an expressive category but rather a fact of "technical" nature, or a form of language imposed by available tools, it is one of the oldest engineering disciplines. The development of Engineering Graphics (EG) is influenced (besides other theories) by semiotics - the theory of signs and symbols and, to some agree, also the theory of meaning-making. Peirce's triadic model can help encode and decode signs – in our case (subject) the engineering drawing, for which there is international agreement that excludes different interpretations and includes the study of how meaning is constructed and understood [2,3]. Engineering and technology students learn basic knowledge, in order to compose engineering drawings as reflections of (physical) existing objects or concepts of future objects (without existing structure), within the EG course. The activity of composing engineering drawings involves also the semiotic activity of classroom participants, who can have different cultural and language backgrounds. A scheme of a triadic pedagogical model is presented in which, according to Peirce's triadic model – object (product identification), interpretant (teacher, student) and represent (teacher, student) – the activity (information processing) is continually transformed through the interpretative collaboration and elaboration by teacher and students (communication), through listening to their feedback and sharing their views (according to teacher's verbal instructions regardless of linguistic limitations, i.e. so-called



visual/verbal learning) and explanations. A model teacher and student in information processing and communication as one of the possibilities for engineering students to solve specific technical problems are presented. One of principal objectives of engineering education is that the acquired knowledge of engineering drawings, based on formal semiotics and graphic conventions, allows to encode (and decode) a technical engineering idea into graphic representations or a 3D model as a medium through which visual images (without existing structure) in the mind of the designer are converted into the real object (product).

## 2. Visualization of engineering ideas in engineering drawing

The technical engineering idea (product identification), i.e. the internal representation, is usually generated in the head of the engineer, serendipitously (Figure 1).



**Figure 1.** Triangular model of observations, ideas and graphics [4].

It means that through spatial thinking in the process of visualization (sketching) and implementation (conceptual design) of engineering ideas identification of a product is understood and its function and form (solid and surface modelling, design analysis) are planned, which ends up with manufacturing (manufacturing simulation, rapid prototypes, technical drawings and documentation) of real technical products and marketing [5].

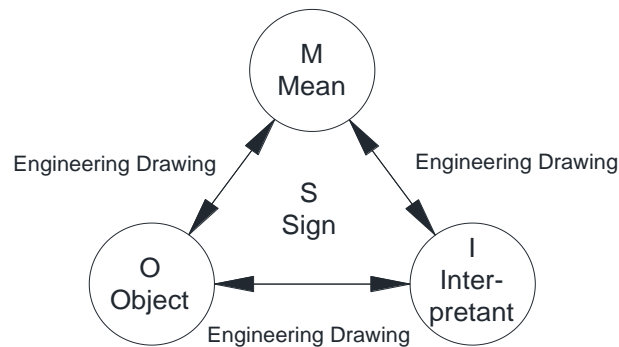
In order that the design idea is unambiguously transmitted (communicated), usually by means of the engineering drawing, the external representation or the so-called design (intercultural) language is acquired within Descriptive Geometry – a theory of geometric shaping and aims to study and understand objects in three-dimensional space (3D) from their two-dimensional representations (2D) in one or more planes; and within EG - creation of a technical documentation course which serves as a basis for developing the principles and methods of expression of engineering drawing. Today, both of these subjects are mainly realized by means of computer aided drawing.

Within the EG course engineering students grasp the fundamentals of graphics: sketching, graphics projection, sectioning, dimensioning, engineering drawing. EG involves correct expression of the engineering design, learning the standards related to working and assembly drawings. After completing the course, the students are able to read and design professional drawings using traditional or modern technology. Concisely: forming of ideas, testing and modifying them, and communication of the result of implementation (conceptual design). It means that the designer works within a spectrum of signs. Parts of these signs are depictions, pictorial – representational images; others are scriptorial, involving words – verbal images. The development of EG is influenced (besides other theories) by semiotics - the theory of signs and symbols and, to some agree, the theory of meaning - making. Thus, whenever meaning-making is involved, semiotics can be applied and its models and methods can be use when one enters the subject field of EG. Peirce's triadic model can help encode and decode signs – in our case (subject) the engineering drawing for which there is international agreement that excludes different interpretations and includes the study of how meaning is constructed and understood [2].

The acquired knowledge of engineering drawings, based on formal semiotics and graphic conventions, allows to encode (and decode) technical ideas into graphic representations or the graphic model as a medium through which visual images (without existing structure) in the mind of the designer are converted into the real object (product).

### 3. From Peirce's triadic model to the semiotic activity of the design process

Peirce's triadic model, the sign-vehicle, mediates between the object and the interpretant and can be applied for transferring the data of the depicted object. Peirce's basic claim is that signs consist of three inter-related parts: the object, the interpretant and the represent [3, 6].



**Figure 2.** Peirce's triadic model (edited by Bense 1983[6]) and Lille et al 2015 [7]) for transferring the data of the design object.

When editing this model for EG, in our earlier study, we regarded the representamen in its narrow sense as the sign itself. In the present context it comprises icons – three-dimensional (3D) drawings or printing, rapid prototyping; indexes – working and assembly drawings; and symbols – graphic symbols of engineering (e.g. technical drawings) [5].

Peirce's notion of the sign offers a good methodological model to the EG student for describing how engineering drawings and depicted objects (details) are inter-related. It is evident that for the existence of signs, there must be somebody who creates and interprets them. Considering the structure of semiosis, the sign is the first, the object that it evokes is the second, and the interpretant is the third, all of which comprise Peirce's ontological categories, see also [8]. The model of a sign (object, representamen, interpretant) defines meaning-making as an infinite process proceeding through the "interpretant", which is based on personal and social experience. Thus it can be also stated that meanings are formed during use. Hence, the interpretant plays a fundamental role in the process of studying EG, establishing a dynamic relationship between the object and the representation and acting through the triadic model [9]; for our adapted version, see Figure 3. Thus interpretation can be influenced both by depicting what is being interpreted and by guiding the interpretant student.

As noted above, engineering drawings as a visual language (for us, characteristically, graphically standardized language) can be interpreted as signs and can be examined also from the semiotic point of view. According to Eco [10], "semiotics resembles medicine in so far as it is a confederation of specialities". Therefore it is not a pure theory, including also representational modes other than language, and as such, only becomes useful when applied to specific contexts, particularly visual design – art, film but also engineering drawing as a specialized branch of it. Yet drawings should not be interpreted differently by different people but should be focused on conveying information in a simple manner. According to the semiotician Y. Lotman, the basic issues in semiotics are the following. What did the author want to convey? Did you understand it [11]? The same applies to the graphic language: "one can draw" and "one can understand a technical drawing" [12], which means that "I" language and "you" language coincide.

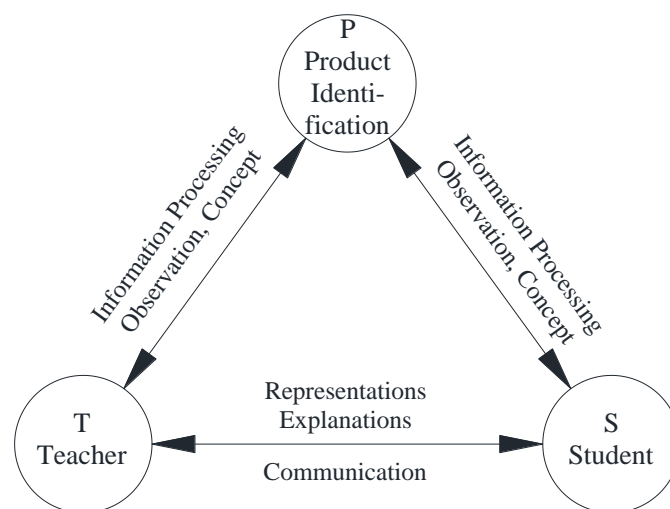
### 4. Semiotic activity in the classroom: teacher and student in information processing and communication

However, in the case of different social groups (for whom the language of instruction in the classroom is a foreign or a second language), they create the meaning of the idea and its representations differently. Culture determines both the meaning of concepts and utterances, which can coordinate an existing internationally accepted pattern of meanings.

According to a Chinese proverb, one picture is worth a thousand words. Still, visual information is often difficult if not impossible to communicate in verbal images (form), e. g. the mathematical

notational form ( $1+1=2$ ), or one plus one equals two. The cornerstone of the designer's work is legality of drawings, which means that any mistake may render the drawing useless. The unambiguity of drawings is of crucial importance as they are usually not addressed to anybody, with the exclusion of an increasing number of cases where the external design is directed to catching customers' attention. Thus the drawing depicts succinctly and laconically what is to be conveyed for manufacturing the product. It is not a piece of art created for enjoyment. At the same time, it improves the readability of the drawing when, in addition to functionality, it has an aesthetic value. This trend has been characteristic of architectural drawings (construction drawings) throughout history.

The activity of composing engineering drawings constitutes also the semiotic activity of classroom participants – the activity which is continually transformed through the interpretative collaboration and elaboration by the teacher and students (communication), through listening to their feedback and sharing their views (according to teacher's verbal instructions regardless of linguistic limitations, i.e. so-called visual/verbal learning) and explanations (interaction between students and between students and the teacher) Figure 3. The presented triadic pedagogical model serves as one option for engineering students to efficiently read and compose unambiguous engineering drawings.



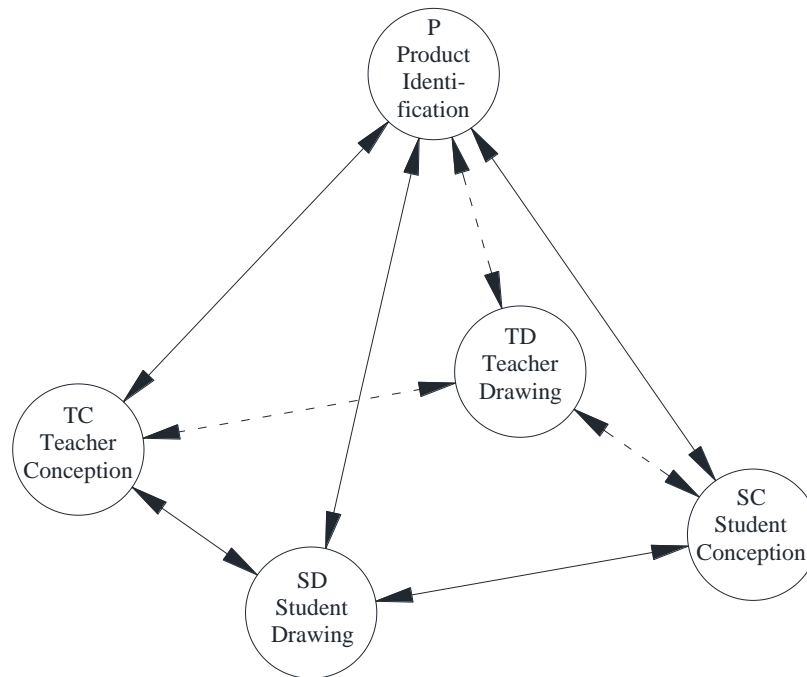
**Figure 3.** Teacher and student in information processing and communication Waldrup et al 2010 [9], (edited by Lille).

Successful application of representational images is not a simple task; it is something that must be trained and used in professional practice. Here we suggest a pedagogical model presented in Figure 3, developed as a triadic model in Figure 4 where problem solving is focused on form. Let us have a problem (P) (product identification) or an existing (physical) object. We have an interpretant-teacher and an interpretant-student who form teacher concept (TC) - teacher representation (TR), and student concept (SC) - student representation (SR), respectively.

First, we consider the behaviour of the model at interpretation of the assembly drawing and the reverse engineering (RE) concept, for analysing the design of an existing (physical) object or so-called reading and writing the drawing [13]. Let the teacher choose some detail. Composing of a drawing on the basis of a detail, an accepted practice in EG, poses a problem for a freshman engineering student. He or she has a problem, teacher representation and student conception (P, TR, SC). The teacher focuses on the essential planes of the detail during which the student gains an understanding of the detail's meaning (where it used) and of the principles of its function. Further, the student develops representational competence which allows him or her to create one's own representation and to learn how to compose adequate drawings of the presented detail.

Second, we consider the design process as the augmented reality (AR) complex of spatial objects, their perceiving and visualization, and consequent writing of the engineering drawing [14]. Advanced engineering students face the problem how to understand a mental representation of an engineering idea

(concept, problem), which would create meaning (individuals need mental power within social and institutional contexts in which meaning-making occurs) and which in turn is expressed by a sign. This suggests use of a triad consisting of the problem, student conception and consequent student drawing (P, SC, SD), as well a triad consisting of the problem, teacher conception and teacher drawing, e.g. rough draft (P, TC, TD). Note, that the representation of an object (future product) can take different forms: icons - three-dimensional (3D) drawings; indexes – working (2D) drawings; and symbols – highly schematized pictures [15].



**Figure 4.** Triadic pedagogical model of Waldrup et al 2010 [9] (edited by Lille).

Here always arises the question how the teacher and student appreciate the adequacy of a representation, since a single representation cannot cover all possible aspect of an object. Consequently, the student needs to learn how to select the representations of the pertinent parts of an object required for manufacturing the real product. Student representations and their revision can function variously as exploratory tools for initial thinking, i.e. scaffolding for building understanding, and records of new thinking and reasoning, depending on the purposes of representations. At all stages of the learning process, the teacher must rely on interpreting students' representations as the evidence of their understanding [13]. It should be noted that what makes a sign the sign is meaning; thus signs and meanings are created as the functionality of objects that are depicted (existing) or that are to be designed (planned).

Peirce's triadic model can help encode and decode signs for which there is international agreement that excludes different interpretations. It is evident that semiotics has the capacity to give meaning to the design process during which something new can be created. The engineering drawing is a clear and coded message relating the design concept to the meaning and communication of the design product. It means that engineering working drawings need to be composed according to an international standard, which will minimize the risk of mistakes. Consequently, they are representations which act through codes and other regularities which do not derive from general laws of physics but are not discordant to them, being historically established. These codes and regularities represent a strictly organized system, originating from the collective memory of a number of one-time engineers (memory always depends on the needs of society or community), which can be divided into different substructures, but their unambiguity has nevertheless preserved [16].

When teaching engineering drawing, this kind of approach may help proceed from the semiotic point of view, as a process of reading and composing of graphic signs among a group of engineering students with different cultural and language backgrounds. Such an approach will definitely regulate



all activity and communication, which could impoverish the modes of expression in one's native language; free exchange of opinion and unexpected debate would be suppressed. Yet, as happens in everyday life, some things remain unutterable, whatever the language, and understanding may be acquired without words, in a visual form, as conveyed by the above Chinese proverbs. Moreover, as far as various conflicts are associated with representation and interpretation in communication, semiotic methods and models could be of assistance in settling or even preventing conflicts.

## Conclusions

A communication model involving teacher and student in information processing as one of the possibilities for engineering students (also with different cultural and language backgrounds) to efficiently read and compose unambiguous engineering drawings is presented.

The drawing is treated as a semiotic sign by applying Peirce's well knowing triadic model involving the object, the interpretant, and the representant. This serves as the basis for a triadic pedagogical model: object – product identification; interpretant – teacher, student; and representation – teacher drawing, e.g. rough draft, student drawing.

The activity of composing engineering drawings involves also the semiotic activity of classroom participants using the triadic pedagogical model – the activity (information processing) which is continually transformed through interpretative collaboration, representations and explanations by teacher and students (communication).

Semiosis as a process of semiotic activity allows realizing the dual function of the semiotic sign by the following designation: the drawing as a sign that denotes an object and the drawing as a sign that evokes making of the object (manufacturing product).

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