DEVELOP CRITICAL THINKING FROM FREEHAND DRAWING TO DIGITAL PROCESSES

Francesca M. Ugliotti[1], Sara Giaveno[2], Davide L. D. Aschieri[1], & Anna Osello[1]
[1]Politecnico di Torino, Dipartimento di Ingegneria Strutturale, Edile, Geotecnica, Torino (Italy)
[2]Politecnico di Torino, Dipartimento di Architettura e Design, Torino (Italy)

Abstract

Learning never stops, and neither does teaching. Stimulating critical thinking at the university plays a critical role in shaping a generation of professionals capable of meeting the ever-changing challenges of the modern world. The experience is related to the course of Building Drawing in the first year of Building Engineering at the Politecnico di Torino. The methodological approach adopted explores the potential of the drawing itself as a language of communication for the construction sector. The course becomes a learning path with the students: theoretical notions are provided as the foundation, then tools and methods for representing the survey and the project between tradition and innovation are analysed and evaluated with a critical attitude. Real-world (freehand sketching), digital (CAD vs BIM), augmented and virtual practices are presented to provide a synoptic picture of possibilities that the student may choose to use in subsequent courses and in working life. The recent pandemic has promoted further opportunities to innovate in teaching by adopting tools that stimulate creativity. The teacher becomes an avatar who can interact with students in cyberspace to evaluate and discuss project ideas. Students are continually asked to self-reflect and assess lesson content by identifying key concepts. The final evaluation also involves a discussion of a mind map in which keywords are put in order, reworked, linked to form a personal interpretation of the teaching. Through the introduction of these actions, it has been noticed an increasing involvement of students, both individually and in groups, leading to the achievement of quality results sometimes higher than required.

Keywords: *Critical thinking, mind map, digital drawing, BIM, virtual and augmented reality.*

1. Introduction

Nowadays, the modern world is faced with increasingly complex challenges related to globalisation, climate change, and the resilience of our cities. On the other hand, the growing technological evolution enables broader and more exciting scenarios than ever. These factors are very evident in the construction sector, which in the Industry 4.0 era is going through a period of structural change to keep pace with the speed of the innovation process. The emergence of digitisation, new working methods and collaborative processes required at the European level by the Directive 2014/24/EU (European Parliament, 2014), such as Building Information Modelling (BIM), have demanded from the market not only new skills at a technical level but, above all, a flexible engineering mindset capable of adapting to fast-changing contexts. This scenario has generated a gap between the new industry's demands and the training of young university graduates. In this historical context, more than at any other time, there was a pressing need to introduce a revision of degree courses (Ugliotti & Osello, 2021), not on theoretical content but approach and teaching method. Moreover, distance learning associated with the Covid-19 epidemiological emergency measures has introduced new difficulties that have required additional investment to turn the limitations of the virtual environment into opportunities for the students (Ugliotti et al., 2021). The article addresses the particular case of the course of Building Drawing in the first year of Building Engineering at the Politecnico di Torino as a leading example of innovative and future-proof teaching practice.

2. Method

Now that the necessity to push for innovation in teaching and learning methods has been framed, how to critically and technically explore it? Moreover, which role plays tools and procedures' for digitalization? This section aims to investigate the strategies that lead to consistent innovation in teaching processes and focuses on the broad theoretical reflection of the current strategies in innovating methods. Promoting innovation in terms of process and tool in teaching courses is driven by specific and tailor-made strategies that aspire to profoundly change the methods and scope of the traditional teaching approach. The Building Drawing course tries to embody these strategies and make them feasible by providing an articulated action plan. The operative strategies adopted in the course are grounded on determined teaching principles focused on improving the use of personal mental strategies in elaborating concepts. The elaboration of information in terms of the connection between topics and matters, individual restitution of results, and critical analysis of process and outcome is fundamental in pushing teaching methods beyond traditional and consolidated procedures. The Building Drawing course tries to embody some of the principles expressed by the cognitivist matrix teaching (Maccario, 2015) and associate the theoretical suggestions with an operative strategy. The teaching approach of the course takes the following strategic principles into account: (i) supporting the reworking of knowledge, (ii) experimenting with mental strategies, (iii) employing the use of mental resources, (iii) increasing the self-efficiency level of the students.

2.1. Reworking of knowledge

First of all, innovative teaching methods should lean on supporting the reworking of knowledge (De Vecchi, 1999). The teaching goal is no longer simply to accumulate a set of knowledge, but to structure, to build networks between concepts. To establish a connection between knowledge. What can benefit the development of an articulated network of concepts is addressing a teaching topic by suggesting the employment of several and different technologies to explore from different sides and grade the same object of study. Providing diversified tools and learning strategies can help in pushing students to build critical thinking and cognitive connections. In this context, the Building Drawing course suggests employing several methodologies and techniques in the cross-sectional analysis of a specific building under study. As the students are only in their first year, they are asked to reproduce an author's project to begin to familiarise themselves with the theoretical content and govern the tools. The case study selected is explored comprehensively by students through a gradual learning path of representation techniques which involves the employment of freehand drawing, bidimensional and three-dimensional digital drawing, parametric design, augmented and virtual reality. The aim, therefore, is not to make a vertical focus, but to investigate the potential and limitations of the different instruments. While the use of freehand drawing is well established in the scientific social research as a tool for critical reflection, the adoption of advanced digital tools is still underestimated in terms of methodological approach. The tools, in fact, represent a means to better control not only the design but especially the process. In this sense, it is important to transfer to students the approach with which to interface with the instruments rather than the mere sharing of commands referring to a specific software popular at the time. The use of different but complementary operative solutions helps students in analysing the object in different scales, various perspectives and technical means. The outcome is a deeper learning of the whole object in its characteristics, in the relationships between the parts, in its connection with the surrounding. The students are asked to begin the process of investigating the building, starting with the creation of anthological sketches. The theoretical contents relating to orthogonal and axonometric projections are declined in the following practical exercises, always requested freehand, having as object a specific characterising element of the artefact. Then digital representations made with Autodesk AutoCAD and Autodesk Revit design model authoring software are compared. The employment of augmented reality is required for the purpose of providing additional layers of information during the presentation of the drawings during the examination. These may include images, videos, virtual tours made from the realised models, websites. Figure 1 shows the example of the Mies van der Rohe Barcelona Pavilion case study from the Building Drawing course a.a. 2020/2021. In addition, students experience immersive virtual reality for their project reviews by using Iris ProspectVR as software, HTC Vive and Oculus Rift as hardware. As can be seen from Figure 2, the teacher becomes an avatar who can interact with students in cyberspace to verify the correct construction of elements and their assembly, dimensions, proportions and construction nodes. User perception is amplified and discussion becomes interactive because it is possible to take note of critical points also by means of instruments for taking screenshots, writing comments and highlighting errors inside the model (Ugliotti et al, 2021). Being able to navigate the digital three-dimensional models at the same time from the inside certainly contributed in terms of collaboration and involvement of the students.

Figure 1. Gradual learning path of representation techniques.

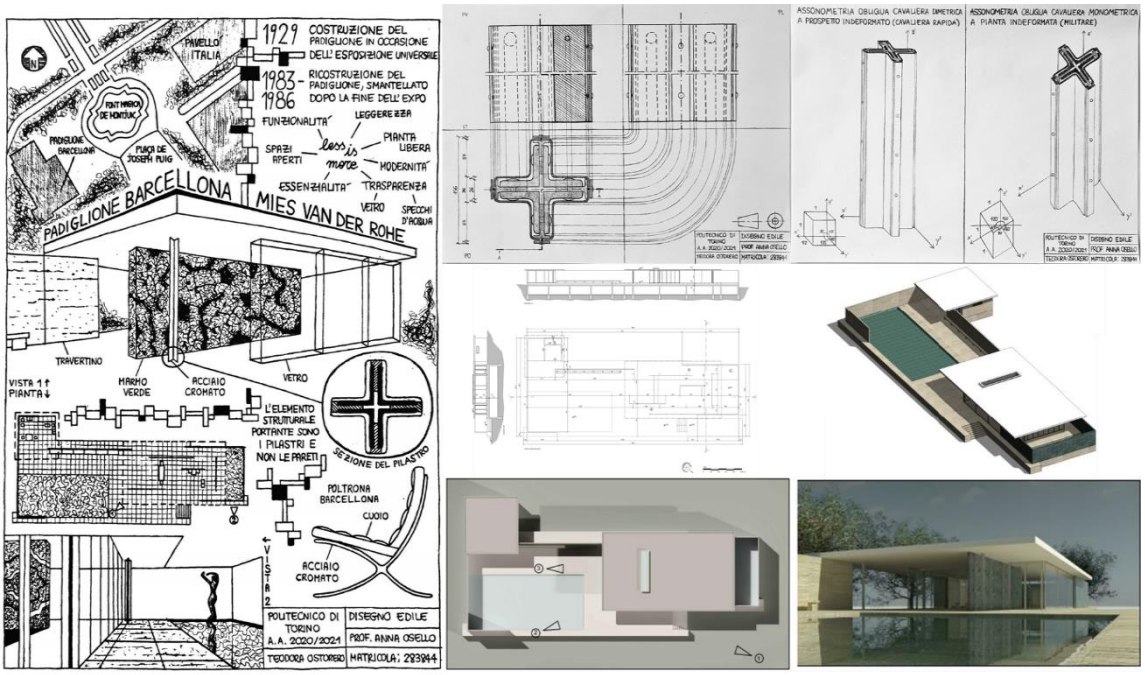
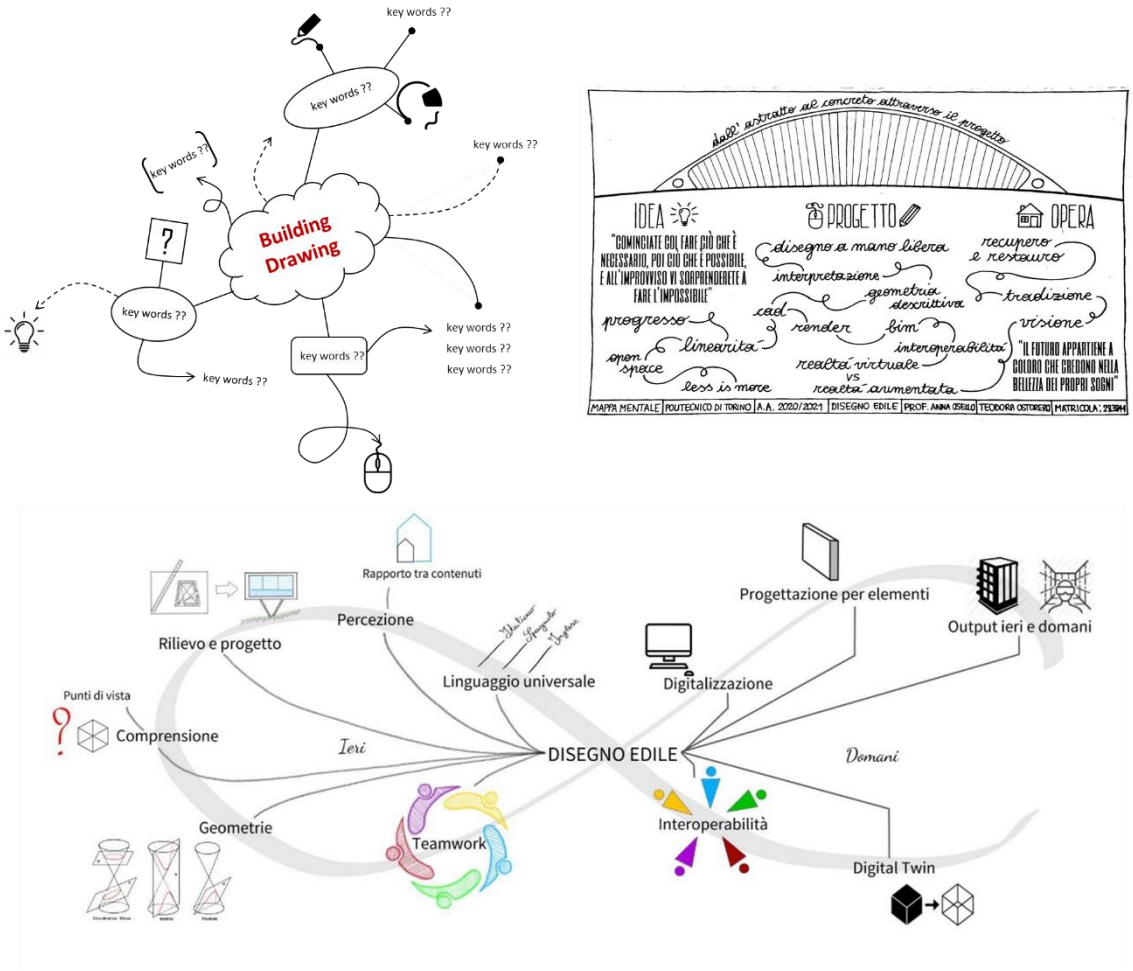


Figure 2. Immersive virtual reality experience for project reviews.

2.2. Experiment with mental strategies

Secondly, teachers should encourage students to experiment with mental strategies to push a step beyond mere knowledge transmission. Knowledge is built through a personal work of re-elaborating concepts through which understanding takes place, and knowledge is established. During the Building Drawing course, students are encouraged to elaborate a personal interpretation of the topics and build mental and graphical connections between subjects. In this framework, an operative strategy could be the definition of a mental map that encloses a keyword for every topic addressed in the course. The student, in this case, has the task of tracing connections between the topics explained and interpreting the contents and the relationships by using a graphical mean. Two examples from the Building Drawing course a.a. 2020/2021 are shown in Figure 3.

Figure 3. Mental maps outcomes.



2.3. Employing the use of mental resources

The teacher not only provides the strategies but also helps students in employing the use of mental resources (Mazzoni, 2001). It is fundamental that an individual is guided to understand that resources must be dedicated during a study activity and, secondly, how many resources must be dedicated and for how long. It is strategic for a student to ask himself how much (cognitive) effort must be used to tackle a task. How to reach this objective? Through a clear organization of the teaching course in terms of topics, objectives, technologies employed, and expected outcome. The task of a teacher is not only to organize the resources but also to help students by employing them at different levels at different times. The Building Drawing course is organized to put different organizational, cognitive and technical resources into action to accompany the subject in its growth as an autonomous individual and student.

2.4. Increasing self-efficacy level of the students

The weaving of the strategies described must lead to the last point of discussion to consider the needed increase in the self-efficacy level of the students. This aspect represents a crucial and fundamental element because it focuses on nourishing the students' cognitive resources in evaluating themselves. It aspires to help students not so much to understand if they have done well or poorly but because they have achieved a specific result. It can positively affect self-efficacy as it helps to evaluate their performance to recognize functional processes and those that are harmful to increase the possibility of self-regulation and the confidence to better face future difficulties. To the advantage of this aspect, the Building Drawing course promotes a calendar organized in weekly steps of validations supported by the teacher, doctoral students, and tutors at different levels and with different and complementary competencies to help students develop practical activities. Students are accompanied in developing their exercises by weekly reporting difficulties and achievements. They are put into proof to have defined a critical and personal reflection on the practical work.

3. Conclusion

The article aimed to illustrate how results in not only the matter intended as the observable learning outcomes but also the strategies used to make them their own. Learning takes place through the organization of knowledge by the subject. A person learns when he can connect the information from outside to his own knowledge to build organized structures. The organization of knowledge leads to the construction of concepts or logical categories that are more and more comprehensive, articulated, and related through logical links. The student must be helped to manage their own learning in an increasingly autonomous way, developing a strategic attitude. The article shows how these theoretical reflections can become practical strategies to make teaching principles feasible. The Building Drawing course is the fieldwork where these teaching and learning objectives are put into action and are experimented into a practical context. The results obtained on the proposed innovative didactic experimentations represent an initial proposal to evaluate the potential of the adopted technologies to support teaching and their impact on students' learning processes based on critical thinking. At the end of the course, students have acquired the competence to critically interpret building form and geometry and the ability to choose the most appropriate representation to achieve a given goal.

Acknowledgements

The authors are pleased to thank all the students of the Building Drawing course of the first year of Building Engineering of the Politecnico di Torino who participated enthusiastically in this advanced didactic experimentation and allowed their work to be shown.

References

European Parliament, *Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC*. (2014).

De Vecchi G., Carmona-Magnaldi N., Della Casa, C. (1999). *Aiutare e costruire le conoscenze.* Firenze: La Nuova Italia.

Maccario D. (2015). *Le nuove professioni educative*. Roma: Carocci editore.

Mazzoni G. (2001). *I processi cognitivi nell'apprendimento scolastico*. Roma: Carocci editore.

Ugliotti, F.M, De Luca, D., Fonsati, A., Del Giudice, M., Osello, A. (2021). Students and teachers turn into avatars for online education. *INTED2021 Proceedings*, pp. 4556-4565.

Ugliotti F.M., Osello A. (2021). Drawing Rediscovers its Intrinsic Multidisciplinary Resilience. *CONNECTING drawing for weaving relationships. Languages Distances Technologies*, pp. 1228 – 1241.