Digi Skills Bsc - Revising Graphic Literacy in Bsc Architectural Design Education through a Software-Based Pedagogic Approach. A Shared Pilot Experience at the Politecnico di Milano

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Abstract

Inspired by the UNESCO/UIA Charter for Architectural Education (Tokyo 2011), since 2020 the digital literacy programme Digi Skills BSc (4 ECTS) is offered to the 2nd year of the Bachelor in Architectural Design at the Politecnico di Milano. Addressed to students who already have a background in classic graphic representation, it aims at experimenting with a paradigm shift from analog to digital, in line with both traditional disciplinary fundamentals and the operational routines characterizing architectural design processes and workflows nowadays. Given the relevance of space in architectural education, 3D geometry-based modeling is the essential chapter in the syllabus. However, an introduction to the parametric and BIM workspaces, as well as some basics of data input (by device, from geoportals and point clouds) and output (visual editing, graphic and physical prototyping) are included as well. Dealing with a variety of software programs and file formats responds to the most challenging UNESCO/UIA expectation that «digital fluency» is encouraged in architectural education. It also led to excellent feedbacks by the about 1.000 students involved. Engaging young generations of scholars from various Universities in the tutorship of the classes (MSc graduates, PhD students and graduates, young researchers), recruited through a national annual call, also published on the UID webpage, was a bet. After two years, it seems to have coagulated into a novel promising research group, which, among other things, also suggested writing this co-authored paper.

Keywords
Digital technologies, dystopia, graphics education, visual representation, distance learning
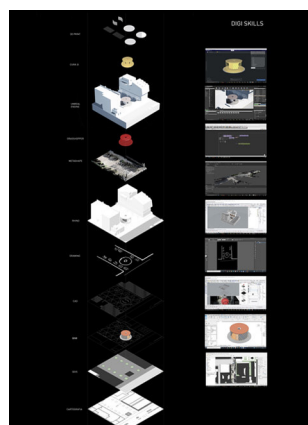
DigiSkills BsC at Polimi: digital fluency at work, a graphic synopsis (original materials from the course).

CURA3D
UNREAL ENGINE
GRASSHOPPER
METASHAPE
RHINOCEROS
ILLUSTRATOR
RHINOCEROS
REVIT
QGIS

Introduction

Although the idea of revising curricula in architectural graphic representation spans a couple of previous decades, the 150th anniversary of the Politecnico di Milano in 2013 offered the chance of discussing the topic in an international and interdisciplinary talk on «The Visual Language of Techniques» [Cocchiarella, 2015]. After a while, an advanced Digi Skills programme addressed to the master's level appeared, mainly focusing on parametric modeling and BIM (fig. 01). More problematic was the implementation of our basic Digi Skills BSc programme addressed to the Bachelor level, due to the necessary connections with analogue graphics literacy as an essential prerequisite. However, in the AY 2020/2021 it was finally decided to start. After two years this work aims to offer a co-authorial retrospect on this experience by the teaching group. The programme is organized in the form of tutorships coordinated by a responsible teacher. In the AY 2021/2022 students were distributed in 20 classes of about 50 students, each taught by a tutor. Despite the short time available (4ECTS), the course would offer a certain systematic approach to the digital processes supporting the real making of an architectural project from concept to form definition and presentation (fig. 02), also related to a narrow urban context. In order to keep a coordinated schedule, the 20 classes worked on the same assignment, that is, a small pavilion ideally located near the entrance to our School.
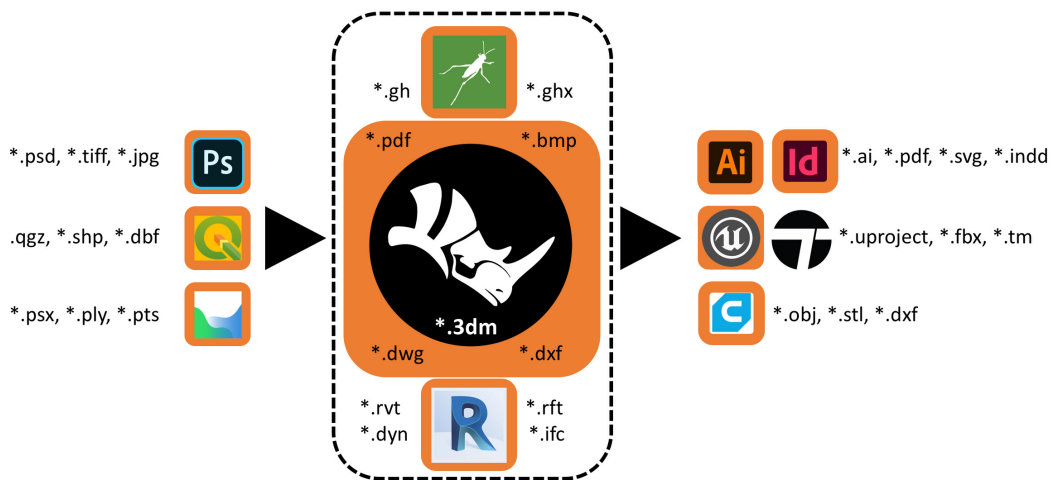
DIGI SKILLS BSc CONCEPT DIAGRAM

Fig. 01. Digi Skills BSc concept diagram: educational goals through a digital workflow _(original materials from the course)
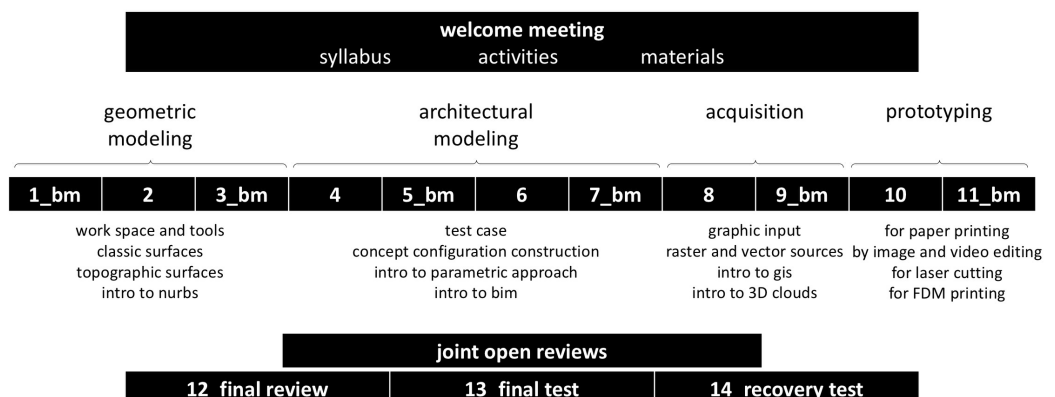
WORKFLOW

Fig. 02. Digi Skills BSc workflow: weekly schedule with contents, letter "bm" stands for plenary meetings of the coordinator with the tutors (original materials from the course)

A plenary meeting with tutors was organized by the responsible teacher biweekly, and tutors were provided weekly with digital ready-made materials for the lectures. During the semester, joint office hours were scheduled with the available tutors. Since distance-learning resulted in being of great help for the coordination and management of the course activities with such a high number of students, we decided to keep it even for the future. A cultural context dominated by the rapid evolution of the digital field encourages a «conscious approach» to computer graphics, based on key principles and updated procedures, to which the proposed *skills* must refer. In our educational view Digi Skills BSc, as a digital graphics literacy programme, should look at a dual goal: offering an alternative way to 'stray' self-directed approaches to the digital tools in the University, and providing acceptable bases for collaborative work and interdisciplinary cooperation in the field of architectural design [Hemmerling & Cocchiarella 2018]. Indeed, according to the UNESCO/UIA recommendations, «digital fluency» may offer excellent bases to open communication channels, for the benefit of both the interdisciplinary exchanges and cooperation, which are maybe the most appropriate educational goals for such a programme in the educational context of a School of Architecture Urban Planning Construction Engineering [Cocchiarella 2021, pp.25-49]. In the following paragraphs, we will propose a series of reflections on specific issues, in order to devise a lifelong learning paradigm also based on a student feedback process, as well as new ideas. At the end of the semester, some students' homework have been selected as «best of» examples in each class, and published on work gallery of the official website of the Bachelor in Architectural Design (fig. 03).
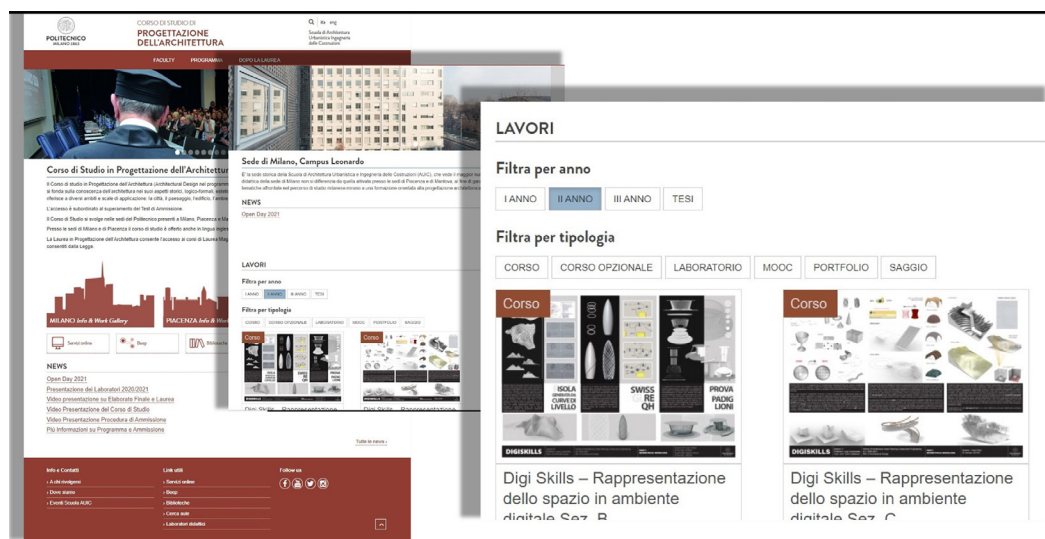

Fig. 03. Digi Skills BSc outcomes: selection of students' works «best of» as it appears on the official webpage of the Bachelor Programme Architectural Design, available in Italian and English [http://www.progettazionedellarchitettura.polimi.it/en/]

State of the art

Aiming at finding and experimenting with an optimal formula based on a codified, disseminable and interoperable teaching method for smart education in digital literacy courses, to be carried out by digital means, a quick look at the state of the art in this field may be of help, besides referring to our experience. The debate about the correct use of digital tools within the educational path and its criticalities vis-à-vis an in-depth preparation of the students was already born in the 90s [Marx 2000, pp. 19-35]. However, it clashes with the potential of the medium, now more established and widespread. The early adoption of such means in the educational study course offers new forms of involvement, and are not limited to offering new creative/planning tools, but also help develop more innovative ideas as well as increase the student awareness of the potential of the tools themselves [Appiah & Cronjé 2014, pp. 85-94].

Hence, the importance of a course that offers an overview of the various available software environment and materials. In fact, several branches of research on education in the architectural sector have already investigated the possibilities of digital tools, with positive feedback on the understanding of notions, acquisition of skills, and competitiveness [Shiratuddin & Fletcher 2007]. On the other hand, other studies highlight the problems related to the excessive focus on aesthetics, the loss of critical sense, and the need for tools that lead the student to correctly evaluate the project. [Guney 2015, pp. 757-765]. In this sense, a comprehensive training providing an overview of today's BIM and parametric systems could compensate for any compositional bias. On the other hand, the forced transition of the academic sector to online teaching in response to CoVid-19, ignited the debate on the quality and compliance of education. Compared to traditional techniques, remote teaching does not seem to fit workshop and teamwork settings [Motley 2017, pp. 229-240], because of the absence of in-person team interaction and direct contact with the teacher; less design practice and live corrections. Furthermore, research showed that workshops were among the most debilitated courses, as their essential experiential-cognitive aspect was missing [Ibrahim et al. 2021, pp. 2345-2353]. However, it has been shown that the teaching of digital tools gains its maximum efficiency through the use of the computer systems themselves [Alhajri 201, pp. 422-425], whereby the students can practice both during the course hours, and autonomously, assimilating secondary notions [Fraher & Martinson 2011, pp.390-412]. The general opinion in the literature on digital design education has raised a series of concerns, ranging from the possible loss of creativity due to standardized means, to its excess fueled by tools that move away from functional judgment. Therefore, this paper aims to verify whether the proposed bachelor course can stay clear of such shortcomings.

Methodology

It is possible to consider Digi Skills as an effective tool to introduce new educational forms in the university system. The online lectures and the possibility to record and review them became the main strongholds of the course and allowed Digi Skills to be accessible to a high number of autonomous students. The experimented methodology allowed us to find a new schedule based on a wide range of software packages that inevitably leads to making the digital approach the real topic. Meanwhile, design and descriptive geometry are taught in parallel and dependent on them. Moreover, the digital approach is based on three main phases: input, i.e. data acquisition; geometric, parametric and BIM modeling; output as visual, graphic and physical prototyping. The three phases are not to be considered separated, rather parts of a single workflow on multiple levels (fig. 04). In addition, the teaching methodology adopted for Digi Skills is based on the learning by doing approach, whereby the students taking part in the lectures are guided to work, independently from one another, on the same project at the same time. An ongoing dialogue between tutors and students is made possible by remote communication platforms overcoming the limits imposed by physical distances. Even with the size of the course, it is important to underline the management of every tutor, who refers to a programme defined and organized in topics and lectures, but free to develop their classes, to schedule student's submissions and manage relationships with students. Finally, we adopted a series of analysis tools to test the results of the course. First, on a weekly basis, students were required to submit assignments related to the classes' topics, which allowed a detailed evaluation of each student's progress along the course. Secondly, they also had to submit a final portfolio – containing the sequence of the topics touched along the course – showing the overall acquired knowledge as well as the proficiency level for each software package. Lastly, at the end of the course, each tutor selected the best final portfolio, informally called "Best Of", as a means to acknowledge the best students' efforts, thus fostering competition among the participants. Even if weekly submissions, portfolio and "Best Of" are important methodological tools, a final exam provides the definitive assessment of the level of competencies achieved by the students.

GEOMETRICAL MODELING
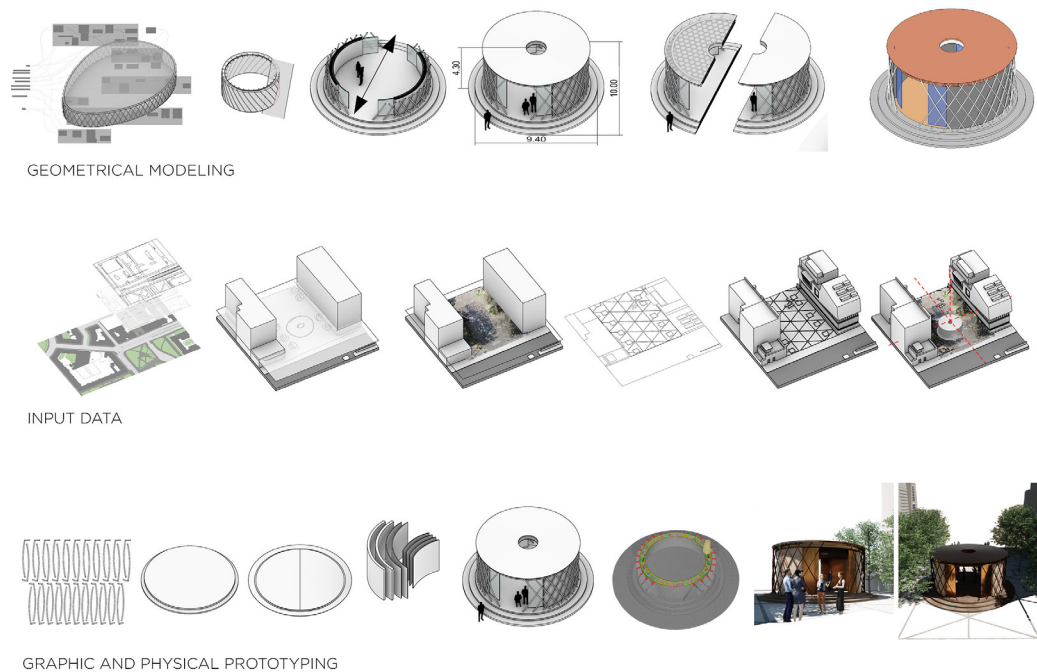
INPUT DATA

GRAPHIC AND PHYSICAL PROTOTYPING

Fig. 04. Fig. 04. Didactic graphic elaboration of the 3 main phases: data acquisition; geometric, parametric and BIM modeling; visual, graphic and physical prototyping (original materials from the course)

Unlike most other courses and workshops such final evaluation is not graded rather is just a pass/fail evaluation vis-à-vis the minimum level of required competencies. In fact, we wanted students to experiment with the software packages freely, without thinking at the final evaluation.

Trials and results

A double retrospective analysis- by- survey of the educational activities is presented here, concerning the students' and tutors' points of view. The survey addressed to the "students group" dates back to the end of the first edition of the Digi Skills courses held in 2020/2021, while the one addressed to the "tutors group" was completed at the end of the second edition, referring to the academic year 2021/2022. Architecture students, who took part in the Digi Skills courses online during the lockdown in 2020, were invited to complete an online survey. The number of students who responded was 547. Figure 05 shows their answers to 9 out of the 11 questions submitted by a simple choice questionnaire with "yes" or "no" as possible answers. Here is a short comment on the results.
Q.01. 94,8% of the students consider the inclusion of this course in the study plan as positive.
Q.02. 98% of them stated to have acquired new knowledge and skills.
Q.03. 92,4% appreciate the fact that this course addressed the use of various software packages and focused on the links among them. Q.04.
Only 5.8% express that knowledge and skills acquired in this course didn't improve their ability to understand and represent the three-dimensional space of architecture.
Q.05. 80% of the students report having changed their vision about digital representation in architecture.
Q.06. 90% of them think that knowledge and skills acquired are effectively usable right away in other courses. Q.07 88% think that what they learned in the course has in some way affected, or could affect, their approach to architectural design. Q.08.
Only 13,8% of the students consider negatively the distance learning experience for this course, while 86,2% express positive opinions on this point. Q.09.

Final survey on the Digi Skills Bachelor experience

0%   100%

Q.01. Do you agree with the inclusion of this course in the study plan ?
   No / Yes

Q.02. Have you acquired new knowledge and skills ?
   No / Yes

Q.03. Did you appreciate the fact that this course addressed the use of various software platforms and the possible links between many of them ?
   No / Yes

Q.04. Do you think that the knowledge, and skills, acquired in this course have improved your ability to understand and represent the three-dimensional space of architecture ?
   No / Yes

Q.05. Do you think that the course has caused, in some way, to change your vision of digital representation in architecture ?
   No / Yes

Q.06. Do you think that the knowledge, and skills, acquired are effectively usable right away in other courses ?
   No / Yes

Q.07. Do you think that what you learned in the course has in some way affected, or could affect, your approach to design ?
   No / Yes

Q.08. Do you think that the distance learning experience for this teaching is positive ?
   No / Yes

Q.09. Would you recommend to implement the distance learning course again next year, regardless of the pandemic situation ?
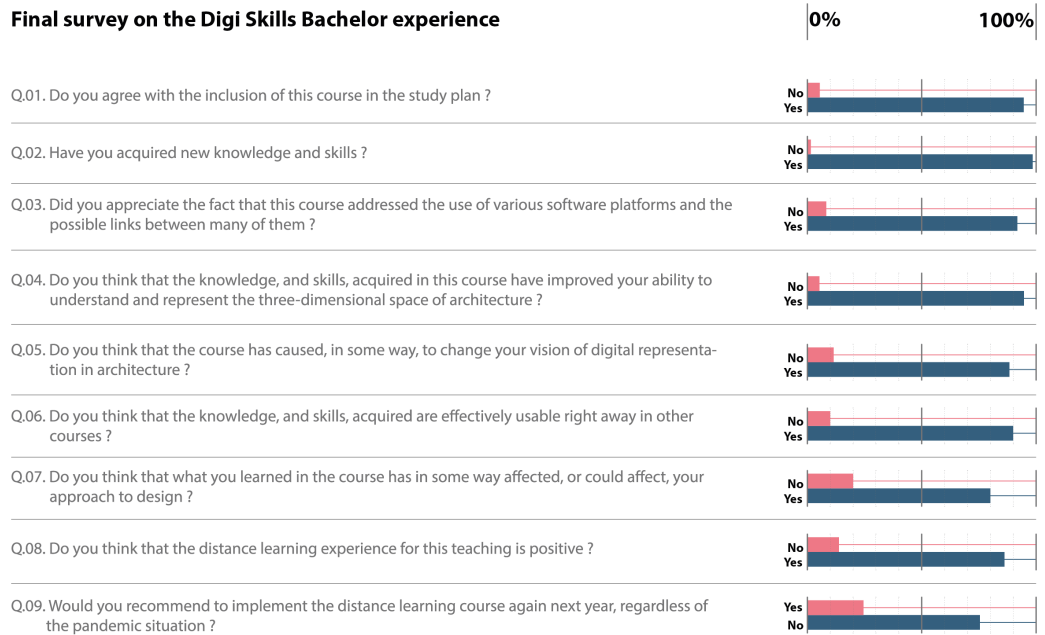   Yes / No

Fig. 05. Students' opinion: summary of the answer trends on some relevant aspects of the courses, AY 2019/2020 _(elaboration by the teaching board)

Indeed, 75% recommend to maintain the remote learning modality for next year, regardless of the pandemic situation. Summarizing the analysis, data gleaned from this study indicate high levels of satisfaction with the programme and educational results as well as with the online learning experience.

The second survey (figs. 06, 07), involving the tutors, was inspired by the use in literature for the analysis online learning (Ref), including teaching monitoring.

Tutors who taught online Digi Skills courses in 2021 have been asked to provide an assessment of their teaching semester, particularly as to some of the tested aspects, such as communication with the class, perception of the class involvement on the topics, teaching organization, communication within the tutoring team, and organizational skills.

Digi Skills Tutors were invited to rate the statements in the survey using both a 6-point (from 0 to 5) scale and an 11-point (from 0 to 10) scale, as well as closed answers.

Observing the results of the tutors group survey, we can notice that communication with the class and the perception of class involvement on the topics, helped them to check students' understanding about the goals. Our survey findings offer a novel perspective regarding communication with the class and with the team, and organizational skills. In fact, 100% of the respondents express satisfaction with the coordination of the work through meetings, arranged biweekly by the coordinator, for the gaining of new knowledge, and also for the effectiveness of the use of remote communication tools in mutual aid among tutors.

Observing the organization of teaching results, we can observe that more than 50% of tutors spent time on extra checks during the exercises and dedicate more time for software programmes like Grasshopper and Metashape. 80% of them also recognize the effectiveness of collective reviews.

As to the time allotment between teaching and interaction with students, more than 40% of the time has been spent on average on the exercises' discussion, and about 20% of time on the homework assignment. Another survey section, regarding the evaluation of results and evaluation methods, shows where tutors need to work to improve the expected results. For example, it shows where the major difficulties lie in the verification of students' homework, and which software packages result particularly difficult for students to learn and apply. Taken together, students' and tutors' group surveys may offer a novel perspective on class goals and outcomes.

Communication with the class

0%   100%

Anticipation of student goals
- No
- Sometimes
- Yes

Students'understanding about the goals
- Frequently
- None

Use of all the communication systems
- No
- Maybe
- Yes

Most used communication mean by students in the lesson
- Vocal speach
- Text-chat

Dialogue outside the classtime
- Never
- Repeatedly

Most used communication mean by students to ask clarifications
- In-class questions
- Appointments
- Mails

Perception of class involvement on the topics

Topics'interest by students
- No
- Yes

Students' dialogue in class compared to face-to-face lessons
- No
- Maybe
- Yes

Dialogue with the students outside the class compared with compared to face-to-face lessons
- No
- Maybe
- Yes

Effectiveness of the dialogue built with the students
- No
- Maybe
- Yes

Suggestions by students for improving the course
- Never
- Frequently

Introducing topics not covered in the course
- Never
- Frequently

Prompty feedbacks on students' requests
- No
- Maybe
- Yes

Organization of the teaching

Class time suddivision
- Introduction
- Theoretical background
- Exercises discussion
- Homework assignment
- Questions

Extra checks during the exercises
- No
- Sometime
- Yes

Software environments improved by extra checks
- Rhinoceros
- Grasshopper
- Revit
- QGIS
- Metashape
- Unreal Engine
- Twinmotion
- Cura3D

Effectiveness of collective reviews
- No
- Maybe
- Yes

Team communication and organizational skills

0%   100%

Coordination of the work by meetings
- No
- Maybe
- Yes

Having skills to implement the basic materials
- No
- Maybe
- Yes

Effectiveness of remote communication tools in mutual aid among tutors
- No
- Maybe
- Yes

Effectiveness of extra sessions with other tutors
- No
- Maybe
- Yes

Gaining of new knowledge by tutors
- No
- Maybe
- Yes

Evaluation of results and evaluation methods

Difficulties in illustrating the goals
- No
- Sometime
- Yes

General satisfaction fo the students
- Dissatisfied
- Accomplished

Difficulties in the verification of the goals
- No
- Sometime
- Yes

Managing the acquisition of students' homework, compared to a traditional course
- No
- Maybe
- Yes

Students ability in the submission of homework?
- No
- Yes

Frequency of the homework verification
- Every week
- Every twoweek
- Every three week

Ideal interval for verification of the homework
- Every week
- Every twoweek
- Every three week

More difficult software for the students to study and implement?
- Rhinoceros
- Grasshopper
- Revit
- QGIS
- Metashape
- Unreal Engine
- Twinmotion
- Cura3D

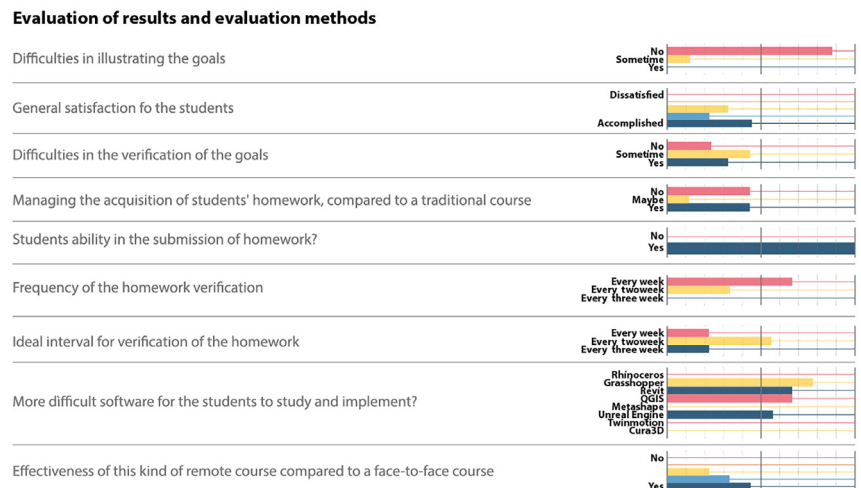Effectiveness of this kind of remote course compared to a face-to-face course
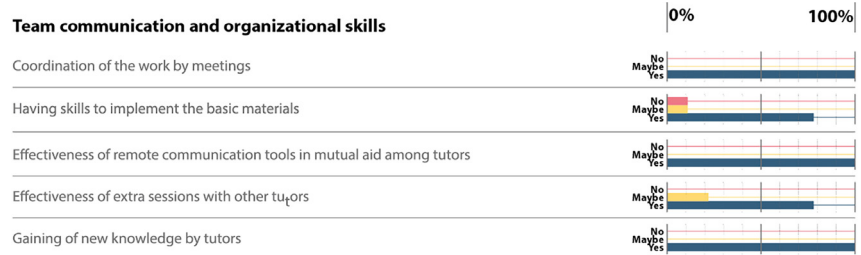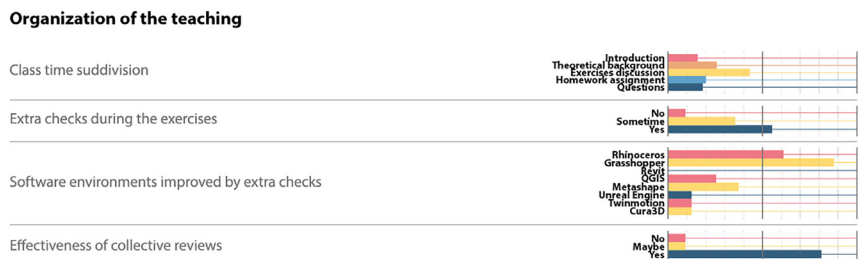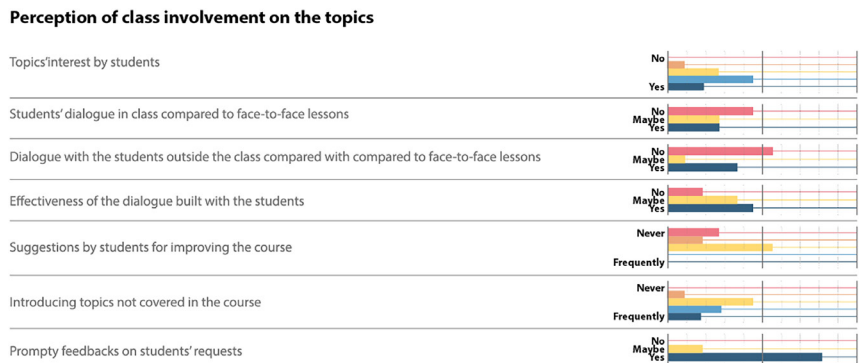- No
- Yes

Fig. 06. Tutors' survey results part 1: answer trend summary on some relevant aspects of the courses, AY 2021/2022 (elaboration by the teaching board)

Fig. 07. Tutors' survey results part 2: answer trend summary on some relevant aspects of the courses, AY 2021/2022 (elaboration by the teaching board)

Potentiality

Digital proficiency, being solidly acknowledged as a universal language, is set to be established as a central component of the Politecnico di Milano curricula and will foster the school mission to be at the forefront of academic didactical advancement and scholar research. Both the distinctive comprehensiveness of the course and the success of its English version in the schools based in Mantova and Piacenza, highlight the scalable nature of a module that could possibly span across several schools and beyond national borders, reinforcing current and future international mobility programs, especially within the EU. Furthermore, the hybrid modalities of teaching and the course flexibility allow for hiring of international profiles, thus enlarging the school network and bringing diversity within members of the faculty of the School. These as well as other potentialities that became tangible during the first couple of academic years will need to be monitored closely in the near future, especially those relying upon feedback data received from the bachelor's and master's experiences.

Conclusions

Digi Skills represents a new frontier in both academic teaching and scientific research. The constant and simultaneous interaction with a wide range of modeling and prototyping software programmes allows students to immediately acquire new knowledge, and to relate themselves with the tutor, whose teaching skills and knowledge about the software, as well as the representational subject itself, increase in turn. It becomes a two-way exchange relationship where the infinite variables and solutions relating to a problem become fertile ground for knowledge and learning. Many students, in fact, succeed, class after class, in acquiring a broader software awareness, and begin to grasp software logic by solving the problems that the lesson requires. The course takes on the role of a workshop/atelier where knowledge is «modeled» to build and acquire new skills and new tools, necessary to interface with a working world increasingly focused on "digital fluency" and on the operational competence of professionals and architects working in the sector.

References

Alhajri, S. (2016). The Effectiveness of Teaching Methods Used in Graphic Design Pedagogy in Both Analogue and Digital Education Systems. In *Universal Journal of Educational Research*, 4(2), 422-425.

Appiah, E., Cronjé, J. (2014). The influence of information and communication technology on graphic design: reflections on pedagogy. In *Journal of Science and Technology* (Ghana), 34(1), 85-94.

Bachelor Programme. Architectural design.
<http://www.progettazionedellarchitettura.polimi.it/en/> (consultato il 17 febbraio 2022).

Cocchiarella, L. (2021). Experiencing Architectural Graphics Literacy. In *Revista Brasileira de Expressão Gráfica,* 9(2), 25-49.

Cocchiarella, L. (a cura di) (2015). *The Visual Language of Technique*. 3 Volumes. Springer.

Fraher, R., Martinson, B. (2011). Process and pedagogy in undergraduate graphic design education. In *The Design Journal*, 14(4), 390-412.

Guney, D. (2015). The importance of computer-aided courses in architectural education. In *Procedia-Social and Behavioral Sciences*, 176, 757-765. < https://doi.org/10.1016/j.sbspro.2015.01.537> (consultato il 30 gennaio 2022).

Hemmerling, M., Cocchiarella, L. (a cura di) (2018). Informed Architecture. Computational Strategies. In *Architectural Design*. Berlino: Springer.

Ibrahim, A. F., et al. (2021). Evaluation of the online teaching of architectural design and basic design courses case study: College of Architecture at JUST, Jordan. In *Ain Shams Engineering Journal*, 12(2), 2345-2353. <https://doi.org/10.1016/j.asej.2020.10.006> (consultato il 30 gennaio 2022).

Kuhn, S. (2001). Learning from the architecture studio: Implications for project-based pedagogy. In *International Journal of Engineering Education*, 17(4/5), 349-352.

Marx, J. (2000). A proposal for alternative methods for teaching digital design. In *Automation in Construction*, 9(1), 19-35. <https://doi.org/10.1016/S0926-5805(99)00049-7> (consultato il 2 febbraio 2022).

Motley, P. (2017). Critique and process: Signature pedagogies in the graphic design classroom. In *Arts and humanities in higher education*, 16(3), 229-240. <https://doi.org/10.1177/1474022216652765> (consultato il 2 febbraio 2022).

Riyanti, M. T., Erwin, T. N., Suriani, S. H. (2017). Implementing Project Based Learning Approach to Graphic Design Course. In *Journal of Education and Practice*, 8(15), 173-177.

Shiratuddin, M. F., Fletcher, D. (2007). *Utilizing 3D games development tool for architectural design in a virtual environment*. <https://itc.scix.net/pdfs/5d2d.content.08674.pdf> (consultato il 3 marzo 2022).

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