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BIM concepts integration in academic education: a cross-sectional analysis

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Abstract

Building information modelling (BIM) has progressively transformed professional practice in building design, landscape analysis, and spatial planning. As architectural and engineering firms have widely embraced BIM over the past two decades, higher education institutions have been pushed to rethink curricula to train future specialists accordingly. Agricultural Sciences, however, represent a discipline where this transition remains largely unexplored, despite its direct relevance to rural building design and agroforestry territory management. This paper presents a cross-sectional analysis of the attitudes and readiness toward BIM integration among Italian university departments of Agricultural Sciences. Data were collected through questionnaires completed by professors affiliated with the scientific sector AGRI-04/C (Rural Buildings and Agro-Forest Land Planning), covering individual familiarity with BIM, perceived curricular relevance, and institutional support for educational innovation. The findings reveal a situation broadly comparable to that of emerging countries in the early stages of BIM adoption: widespread enthusiasm among individual academics is rarely matched by institutional commitment, specialized awareness, or concrete implementation strategies.

Key words: BIM; academic curriculum; rural building and landscape design; Rural Buildings and Agro-Forest Land Planning.

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Introduction

Building information modelling, better known with the acronym BIM, is revolutionizing the way we conceive the patterns, protocols and procedures of building and landscape design. BIM adoption began with the Nordic European countries in the early 2000s. Since then, various nations have implemented it, including the UK, South Korea, and other European countries between 2016 and 2019 (Al Aamri *et al.*, 2025). As for the level of integration of BIM concepts into the academic curriculum, BIM education has been adopted very early in America (Li *et al.*, 2020), while it has different consideration in other countries and regions (NATSPEC BIM, 2025). The specialist scientific literature has been expanding in the last years and offers several definitions of BIM, according to the many cultural, technological, and professional contexts of application (Borkowski, 2023). Combining major definitions, BIM can be meant as an overarching framework allowing the cooperative design and management of buildings and landscapes in digital format from the first premises of the project to the last dismissal operations (Zamora-Polo *et al.*, 2019). In a virtuous cycle, for its powerful features, the adoption of BIM concepts in practice is recently boosted by the adoption of international and national regulations that make it mandatory in the management of public works (European Committee for Standardization, 2018a, 2018b; European Union, 2014; Republic of Italy, 2023). The first pioneering experiences of BIM regarded the domain of building architectural design (Wang *et al.*, 2025), but in recent times it has been affecting spatial, environmental, and landscape planning in a powerful integration with geographic information system (GIS; Nikologianni *et al.*, 2022). The focus of BIM application is still on urban areas, while rural houses and built-up and natural landscapes represent an expanding frontier (Gao, 2023; Han and Ran, 2023; Yaji and Xiaoqian, 2023; Zhou *et al.*, 2023). Agro-industrial building design and management have attracted less attention, although examples of BIM-based approaches can be found in the educational academic context as in Ledda *et al.* (2025), who reported on BIM application to the design of dairy cattle in Sardinia, Italy (Spagnolo, 2020). Moreover, the use of BIM enables the modification of building structures to accommodate different livestock categories (*e.g.,* cattle, sheep, pigs), incorporating species-specific functional and environmental considerations into the design process (ACCA, 2025): in this regard, "BIM is ideal for designing and managing agricultural buildings as well" (Khan *et al.*, 2018). The agro-industrial building design and management represent an interesting field of experimentation (Ledda *et al.*, 2025).

The transition from computer-aided design (CAD) to BIM rationale is not straightforward worldwide, even in architecture, engineering and construction (AEC) sectors. It requires mature contextual circumstances involving institutions, professionals, processes, hardware and software, training and continuous higher education (Szafranko and Jurczak, 2024). As for the educational aspects, the higher demand of BIM skilled professionals urges higher educational institutions to renovate the courses of building design and landscape planning (Barison and Santos, 2010). The transition mobilizes instructors, students, human and financial resources, and infrastructure (Ramadhan *et al.*, 2022) and implies a range of measures, from the integration of existing programs to the design of new programs (Kovacic *et al.*, 2015; Safour and Ahmed, 2023). The restructuring of the academic curriculum is a demanding process, whose progress can be monitored and comparatively appreciated, through the design of specific BIM academic education assessment frameworks (Ledda *et al.*, 2025).

With respect to the background issues above, in this paper we aim at reporting and discussing the outcomes of a survey on the level of integration of BIM concepts into the academic curriculum offered by some Italian university departments focusing on agricultural and forestry sciences. Inspired by the assessment framework proposed by Ledda *et al.* (2025), we designed a questionnaire concerning well-known major issues characterizing the educational transition to a BIM-led curriculum on rural building design and rural landscape analysis and planning. The questionnaire was submitted from June to September 2025 to the community of scientists belonging to the scientific Rural Buildings and Agro-Forest Land Plannin (ministerial code AGRI-04/C); twenty-four questionnaires were filled in, and the answers have been analyzed and clustered according to the following research questions (RQs). RQ1 investigates BIM educational transition and regards basic concepts, such as focus of application, type of educational program, and software adopted. RQ2 inquires on how BIM concepts are mastered by considering the operational issues: level of implementation of BIM concepts and typical bottlenecks. RQ3 screens on how BIM concepts are transferred by delving into the learning experience, students' and instructors' BIM principles background, and interaction.

The argument of this paper is exposed as follows. In the next section, we illustrate the methodology used by describing the rationale of the questionnaire framework submitted. In the third section, we describe the target of the questionnaire and present the outcomes, by illustrating the patterns of the replies. In the last two sections, we discuss the outcomes with respect to the RQs and present the final considerations of this exercise.

Materials and Methods

Inspired by Ledda *et al.* (2025), we designed a survey including questions related to issues very frequently reported by the international literature on BIM concepts integration in academic education. In Table 1, we report on the structure of the survey by illustrating the questions and the corresponding answer type and predefined entries. The fourteen questions submitted belong to three macro issues: basics, implementation, and educational experience. The first macro issue includes questions Q1-Q6 aiming at acquiring information on the general attitude of the interviewee for BIM concepts in technical practice and educational experience. In this respect, focus of BIM application (Q1), familiarity with BIM principles (Q2), mandatory BIM use for certain design domain (Q3), BIM education integration need (Q4), ways and levels of BIM-led integration in academic education (Q5-6) are major issues in the sectoral scientific literature (Alshawabkeh *et al.*, 2021; Krivonogov *et al.*, 2018; Leite, 2016; Liu *et al.*, 2020; Nakapan, 2011; Nikologianni *et al.*, 2022; Peng *et al.*, 2022; Pontrandolfi, 2020; Safour and Ahmed, 2023; Wang *et al.*, 2025). The second macro issue embraces questions Q7-Q10 on the characteristics of BIM implementation with the objective of clarifying the level of BIM concepts proficiency of the interviewee. BIM dimensions (Q7), user maturity level (Q8), level of development (Q9), and software adoption (Q10) are well known assessment frameworks and instances by the specialists in the field (Alshawabkeh *et al.*, 2021; Barazzetti *et al.*, 2015; Bew and Richards, 2008; Fernández-Mora *et al.*, 2022; Han and Ran, 2023; Huang, 2018; Khan *et al.*, 2018; lot Tanko and Mbugua, 2022; Mawra *et al.*, 2024; Pillay *et al.*, 2018; Raya and Gupta, 2022; Sampaio, 2015; Saraireh *et al.*, 2020; Szafranko and Jurczak, 2024; Wang *et al.*, 2025).

The third macro issue involves questions Q11-Q14 on the educational experience of the interviewees, with the objective of understanding the level of readiness to deal with BIM concepts of students and instructors, the type of student autonomy in learning, and the bottlenecks to academic transition to BIM-led courses. Students background exposure to BIM (Q11), instructors' training (Q12), student-teacher interaction (Q13), and barriers to integration of BIM concept in the academic curriculum (Q14) have been largely studied in the scientific literature (Abbas *et al.*, 2016; Barison and Santos, 2010; Huang, 2018; Peng *et al.*, 2022; Suwal *et al.*, 2013).

Questionnaire submission and results

The questionnaire was managed through Google Forms and submitted from June to September 2025. It was conceived as a pilot *i.e.*, a preliminary release to validate clarity of the questions, overall answerability, language clarity, and efficiency of the delivery mode. So, we drafted the list of questions by addressing their contents to core issues emerging from the scientific literature. This scientific reference was conceived to apply a very preliminary expert validation. We plan to carry on the remaining steps of the questionnaire validation (*i.e.* data cleaning, statistical analysis, and refining) in future research works. The interviewee has been introduced to the themes of the questionnaire through a short paragraph reported in the *Appendix (online supplementary material)*. Although the survey involves data extracted from human replies, the anonymization process prevents any possibility to trace back the answers to the identity of the interviewees. Thus, we verified that in this case of low risk, the consent of the ethics committee was not needed. The target was a set of academic colleagues belonging to the second section of the Italian Association of Agricultural Engineers (AIIA) and to the Italian scientific sector dealing with Rural Buildings and Agro-Forest Land Planning (with ministerial code AGRI-04/C). As per November 2025, the Italian ministerial database of colleagues in the AGRI-04/C sector included 61 scientists, who mostly belong to AIIA. Twenty-five colleagues answered. They belong to academic bodies located throughout the whole nation in (from north to south) Milan, Bologna, Pisa, Florence, Ancona, Perugia, Sassari, Viterbo, Naples, Bari, Foggia, Matera, Reggio Calabria, and Catania. They mostly work in university departments dealing with agricultural, forestry, and food sciences and hold the following positions: full professor (7 people), associate professor (15), assistant professor (1), and post-doc (2). In the remaining of this section, we report on the answers to the questions clustered by macro issues. The replies to the questions of the basic macro-issues are described in Figure 1. As for Q1 (Figure 1A), replies indicate that colleagues mostly focus on building design or on both building and landscape design with a marginal pure interest in landscape design. Figure 1B on question Q2 clearly indicates that the interest in BIM applications is still characterized by absence of operational practice (14 out of

Table 1. Details of the survey: questions, type of answers, and predefined entries.

Macro issues	Code	Question	Type of question	Predefined entries: figure's short tag
Basics	Q1	What is the focus of your BIM applications?	Closed ended with one tick possible	Building design, landscape design, both building and landscape design, I can not indicate any focus
	Q2	Are you familiar with Building Information Modelling (BIM) concepts for the design, construction and management of buildings and landscapes?	Closed ended with one tick possible	Not at all, I heard of but I never practiced, I practiced for at least two years, I practiced for at least five years, I practiced for at least ten years and have a professional control of
	Q3	Are you acquainted that the use of BIM is mandatory for the design, construction and management of certain public works?	Closed ended with one tick possible	Yes, No, Maybe
	Q4	What is your perception of the need to integrate BIM concepts in the academic curriculum?	Closed ended with one tick possible	No need, Moderate need, Urgent need
	Q5	How are you involved in processes of BIM concepts integration in the academic curriculum?	Closed ended with one tick possible	Early stage (restructuring existing single courses or diploma final thesis): Early, Intermediate stage (creating new single courses): Intermediate, Advanced (creating new educational programs): Advanced, None of the above: None
	Q6	At which level are you involved in BIM concepts integration in the academic curriculum?	Closed ended with more ticks possible	I am not involved: None, Undergraduate (three-year degree program): U, Graduate (two-year degree program): G1, Graduate (post lauream degree program: master, ...): G2, PhD program: PhD
Implementation	Q7	Which dimensions characterize your BIM applications?	Closed ended with one tick possible	2D for bi-dimensional CAD, 3D for three-dimensional CAD-BIM, 4D for construction scheduling and time management BIM, 5D for cost management BIM, 6D for sustainability and energy BIM, 7D for entire life cycle BIM, 8D for security BIM, 9D for lean construction BIM, 10 D for industrialization BIM, I can not indicate any option corresponding to my BIM applications
	Q8	Which is your BIM user maturity level?	Closed ended with one tick possible	Level 0 for CAD user, Level 1 for stand-alone 2D and 3D modelling, Level 2 for collaborative BIM, Level 3 for iBIM with integration and interoperability, I can not indicate any level corresponding to my BIM experience
	Q9	Which is your BIM Level of Development (LOD)?	Closed ended with one tick possible	100 for the basic form (standing for shape, size, and location): 100, 200 for the generic form: 200, 300 for specific form: 300, 350 for actual model of product including its form: 350, 400 like to 350 with fixing, assembly details and information: 400, I can not indicate any BIM LOD: None
	Q10	Which software have you used for BIM applications (none for no application)?	Open ended with more ticks possible	Software programs denomination proposed by the interviewee and standardized by the Authors Educational experience
Educational experience	Q11	Which was the students' background exposure to BIM concepts?	Closed ended with one tick possible	None (lack of previous exposure to BIM concepts): None, Basic (starting exposure to the basic concepts of stand-alone BIM concepts): Basic, Advanced (complete exposure to integrated, interactive and interoperable BIM concepts): Advanced, None of the above
	Q12	Have you received (self) training to teach and coach on BIM concepts?	Closed ended with one tick possible	None, Two-year training, Two to five year training, More than five year training
	Q13	Which was the typical student-teacher interaction?	Closed ended with one tick possible	Autonomous (very autonomous and proactive student and minimal coaching over BIM concepts and application): Autonomous, Semi-autonomous (moderately autonomous student and some need of coaching over BIM concepts and application): Semi-autonomous, Teacher dependent (not autonomous student and continuous need of coaching over BIM concepts and application): Teacher dependent, None of the above
	Q14	Which are the typical barriers to BIM concepts integration in academic education?	Closed ended with more ticks possible	Conceptual (lack of understanding of the process): C, Technical (difficulties to use the required tools): T, Environmental (circumstances of the learning environment): E, None of the above: None

25 colleagues) but also by at least 2 years practice (11 colleagues). As indicated by Figure 1C on question Q3, most colleagues are acquainted with the mandatory use of BIM for certain public work design management. According to the results reported in Figure 1D on question Q4, almost all the colleagues in the sample (24 out of 25) feel that a transition to BIM-led design education in academy is moderately or urgently needed. With respect to Figure 1E on question Q5, 13 colleagues are not involved in any process of integration of BIM concepts into academic curriculum, while 8 colleagues are reshaping an existing course or diploma program. As for Figure 1F on question Q6, most of the interviewees are not integrating BIM concepts into the academic curriculum at any educational programs, while many colleagues are doing so at least in undergraduate programs. In Figure 2, we report on the replies to questions Q7-Q10 included in the second macro issue on BIM implementation. Figure 2A on question Q7 shows that 11 out of 25 colleagues cannot indicate any specific dimension of their BIM applications, while other 11 colleagues declare to practice a 3D BIM application. As for Figure 2B on question Q8, 10 colleagues can not indicate any maturity level and only 3 colleagues use BIM application at level 2 (collaborative way). As Figure 2C on question Q9 indicates, 13 colleagues can not indicate any level of development and 9 colleagues practice at level 100 or 200 (basic and generic form). Finally, Figure 2D on question Q10 illustrates that 11 colleagues do not use any BIM software and Autodesk Revit and Graphisoft ArchiCAD are major options. In Figure 3, we report on the replies to questions Q11-Q14 included in the third macro issue on BIM educational experience. Figure 3A on question Q11 illustrates that students have no specific background on BIM concepts and in many cases the interviewees cannot indicate any option. According to Figure 3B on question Q12, most teachers did not receive any specific training to teach and coach on BIM concepts. As for Figure 3C on question Q13, in a few cases, the students were autonomous in mastering BIM software and concepts, while many interviewees could not indicate any type of interaction. Finally, Figure 3D on question Q14 indicates that with the largest share the interviewees did not indicate any barriers to BIM concept integration in academic education, and in second instance they mentioned technical bottlenecks.

Discussion

In this section, we provide the reader with a contextualization of the outcomes illustrated above. We do so, by advancing some

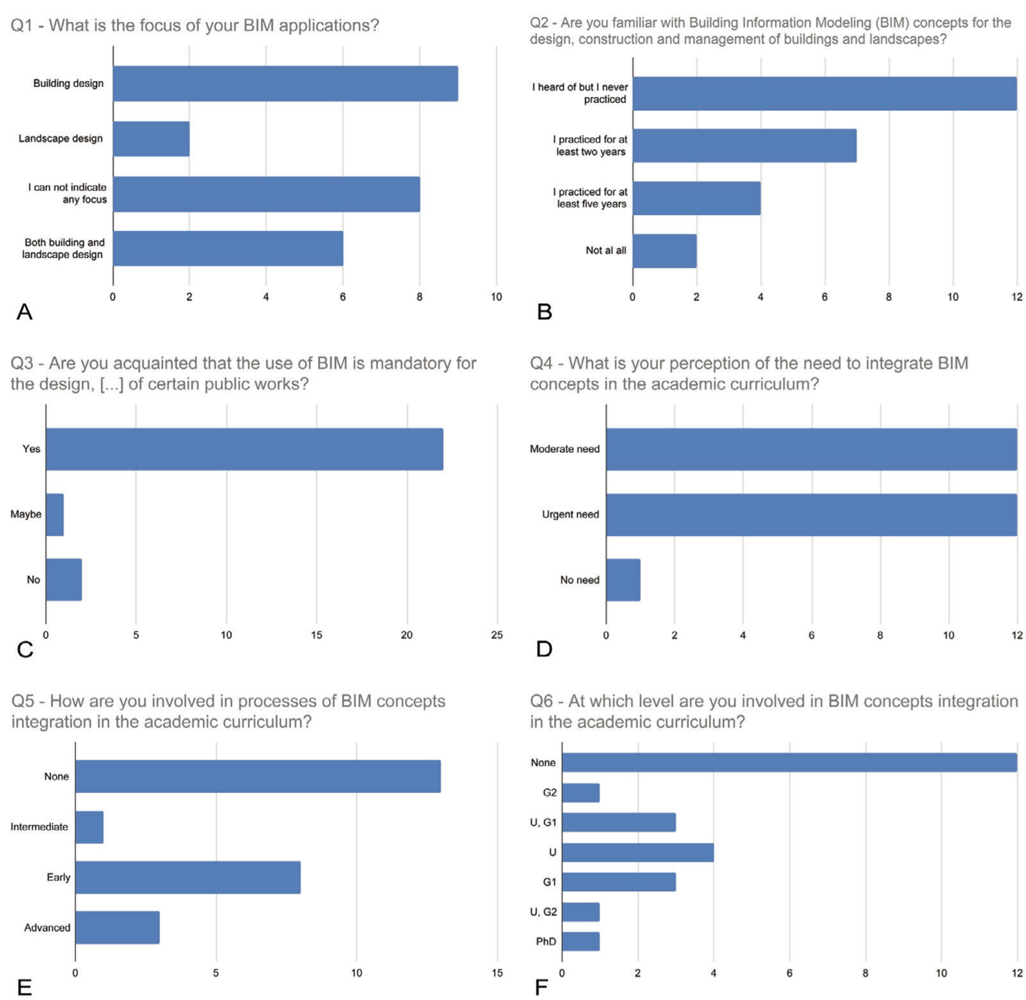

Figure 1. Answers to questions Q1-Q6 of the first macro issue of the questionnaire (Basics). See Table 1 for the meaning of short tags.

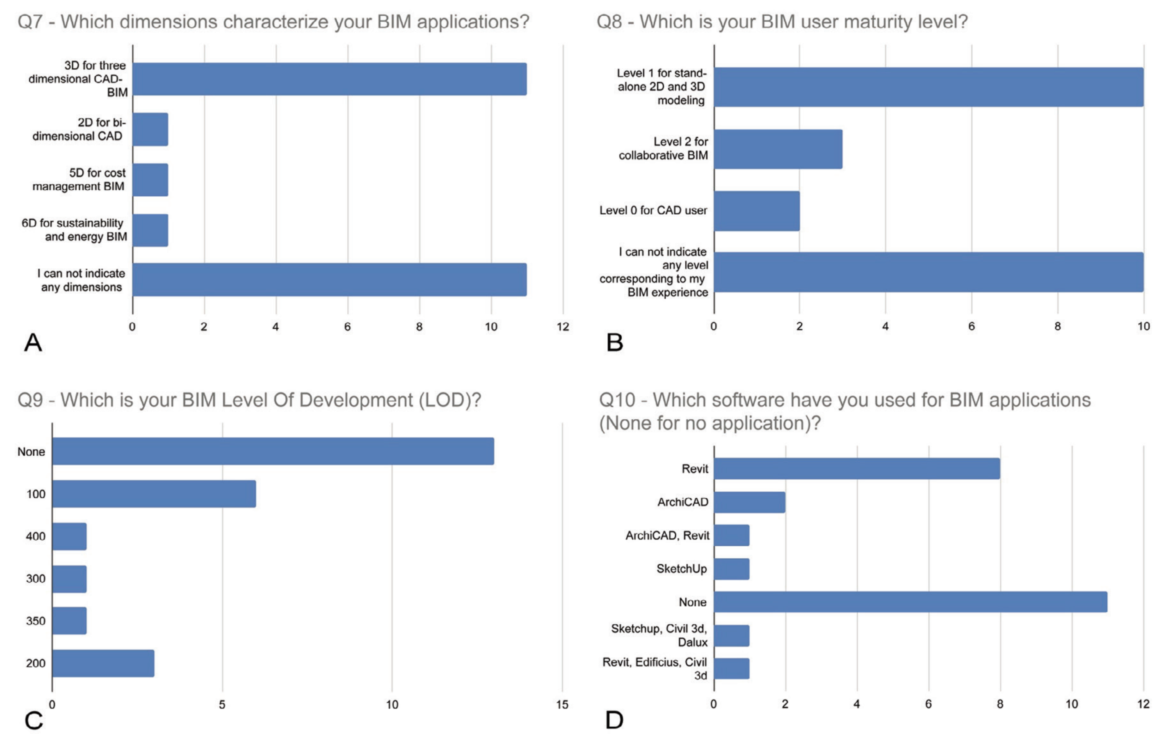

Figure 2. Answers to questions Q7-Q10 of the second macro issue of the questionnaire (Implementation). See Table 1 for the meaning of short tags.

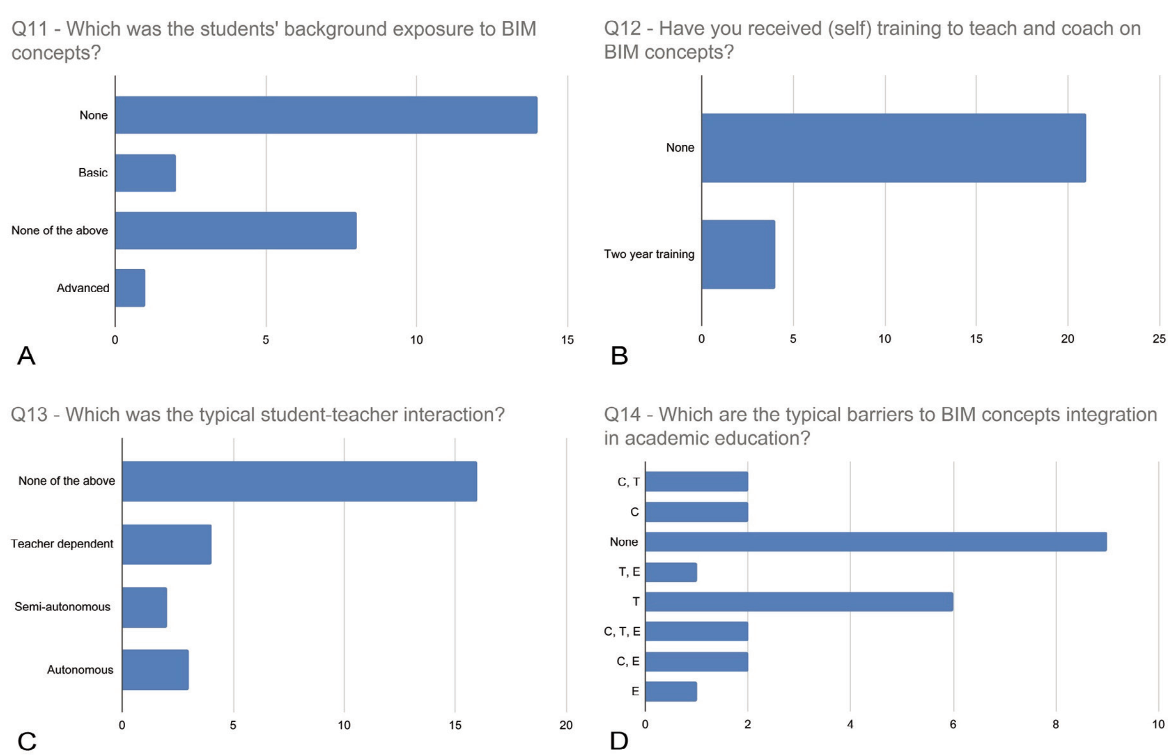

Figure 3. Answers to questions Q11-Q14 of the third macro issue of the questionnaire (Educational experience). See Table 1 for the meaning of short tags.

general arguments and developing on the RQs and related macro issues proposed in the introduction and methodological section.

A first general consideration attains the sample considered. The set includes twenty-four replies out of 61 potential interviewees and absorbs a share equal to nearly 40% of the universe of academic colleagues belonging to the Italian ministerial sector AGRI-04/C Rural Buildings and Agro-Forest Land Planning. The share can be considered satisfactory: the repliers show academic affiliations evenly distributed throughout peninsular and insular Italy and a working profile pattern mostly representing permanent positions (full and associate professor). So, young research assistants have replied in a very limited way to the questionnaire. A second general consideration attains the high frequency of "none" or "none of the above" or "cannot say" replies. This is a clear signature that -beyond the generic statements on the need to transition the academic curriculum towards BIM-driven educational programs- the colleagues are frequently not familiar with the technicalities and the specifics of BIM. This evidence is compatible with patterns observed in academic realms of emerging BIM adopters (countries at an earlier stage of BIM maturity), where the interest in BIM concepts integration in educational programs is generally in its infancy (Ledda *et al.*, 2025; NATSPEC BIM, 2025).

As for the first macro issue attaining the basics of BIM (RQ1), the colleagues of the sector Rural Buildings and Agro-Forest Land Plannin focus mostly on building design but are also applying BIM to landscape management and planning. This is in line with the general attitude of the AEC sectors toward the design of single or group of units but reveals openness to territorial analysis in integration with GIS and terrain 3D modelling tools. This declaration on the focus of the application is to be confronted with a poor level of familiarity with BIM concepts, as the repliers frequently declare no practice. Similar comment holds for the widespread acquaintance of the need to use BIM for certain public works. In a similar way, replies to Q4-6 illustrate that the large adhesion at least to a moderate need of evolving academic design education into BIM-driven curricula does not always lead to operative mobilization of the colleagues in significative and systemic academic educational innovation processes. This gap between theoretical statements and practical commitment is typical of emerging BIM adopters in the worldwide transition to BIM academic education (NATSPEC BIM, 2025). The awareness of the need to teach BIM concepts in higher educational institutions is confirmed in other studies (Eadie *et al.*, 2014). Similarly, the emergence of circumstances hindering a smooth transition from traditional 2D tools to 3D BIM software routines is documented also in other research studies (Huang, 2018). The educational unbalance recorded in our investigation with a large focus for undergraduate and master's programs should be confronted with the recall to the renovation of the broadest spectrum of academic programs (including PhD level course and open seminars) (Sampaio, 2015). Finally, the general endorsement for BIM concepts integration in academic education of advanced building design is documented in other studies (Liu *et al.*, 2025), where BIM (together with fundamental of construction and artificial intelligence and big data) is deemed to be key for the preparation of future professionals in intelligent construction. As for the second macro issue on BIM implementation (RQ2), replies to Q7-10 confirm the theoretical approach to BIM emerging from the responses to the first six questions above. This is clearly proved by a null use of software programs by nearly a half of the respondents, a maturity level 1 (stand-alone applications) or less for 22 interviewees and LOD 100 or less for 19 repliers. This may be partly explained by the position of the colleagues dealing with multiform academic duties and with very spare time for executive tasks. A stronger institutional commitment to the transition to BIM-led education can justify the allocation of time and resource to attain and maintain higher consciousness and technical command of BIM frameworks. The use of proprietary software programs -such as Autodesk Revit and Graphisoft ArchiCAD- requires structural funding and informatic technicians support for educational multi-licence purchasing and design laboratory management. Many issues recorded in our study correspond to worldwide phenomena. As for software programs, Kovacic *et al.* (2015) and lot Tanko and Mbugua (2022) have documented the use of similar tools. In detail, Alassaf (2025) illustrated the efficiency of Autodesk Revit for overcoming learning barriers. The urgency of providing more instructor academic education is recalled by Muller *et al.* (2016). This strategy is believed to overcome the low familiarity and use of BIM concepts (Pillay *et al.*, 2018), increase the overall institutional maturity *(i.e.*, a comprehensive concept encompassing also BIM maturity level and level of development; Safour and Ahmed, 2023), and move from initial modelling to collaboration in BIM-driven design (Correa *et al.*, 2025). As for the third macro issue on learning experience, many replies confirm the theoretical approach to BIM education, with a weak consciousness of the educational challenges involved in such innovation processes. This is witnessed by the large number of "none" replies to all the Q11-14. The generally low exposure to BIM training of the instructors is a clear symptom of the absence of a sustained interest of academies to address a specific educational innovation in the field. The evidence is well-paralleled by the replies-to-Q14, which allude to contextual and environmental -i.e. organizational- beyond the technical- barriers to a smooth academic educational evolution to a stabile supply of BIM integrated curricula. With systemic efforts, we exert no doubt that the autonomy of students will be expanded even with a poor background on BIM concepts. The early-stage circumstances characterizing the educational environment have been documented in other cases by the study of Alnaser *et al.* (2024) on skill gaps, of Barison and Santos (2010) on institutional lags, and of Huang (2018), Ismail *et al.* (2024), Szafranko and Jurczak (2024) on general barriers to BIM integration in the academic curriculum. The solution of these critical circumstances should be found through paths of progressive implementation and maintenance of an ecosystem of BIM technologies supporting the broad academic learning community (Adamu and Thorpe, 2016).

Conclusions

In this paper, we present and discuss the outcomes of a cross-section analysis concerning the attitude of Italian teachers to transitioning building design and landscape planning educational programs to a BIM-driven curriculum. We extend the evidence of a study by Ledda *et al.* (2025) concerning the Department of Agricultural Sciences at the University of Sassari (Italy) to the broader panorama of many other similar Italian academic departments. This generalization is achieved by gathering the replies to a questionnaire attaining well-known and accepted scientific issues on the basics, implementation and educational experience of BIM academic educational transition. In this respect, the method is designed in a universal way and can be applied to the cross-section analysis of other academic communities engaged in BIM educational transition. The main message of this analysis is that the community of Italian agricultural engineers working on Rural Buildings and Agro-Forest Land Planning shows a very promising attitude for a BIM-inspired innovation of the academic education. Meanwhile, this theoretical awareness does not always lead to practical educational endeavors. This circumstance might be associated to the emerging BIM adopters nature of some Italian higher education institutions and by a still marginal role played by agricultural sciences departments with respect to core architectural and engineering departments. This calls for urgent mobilization and institutional commitment of agricultural sciences departments with respect to the use and teaching of BIM concepts for the design of rural buildings and landscapes. The BIM ecosystem could be set up as an interdepartmental infrastructure involving funding, technicians, instructors, students, hardware, and software in an integrative perspective. The outcomes of this study are meaningful within some limitations that open to further research work. First, the interviewee sample size is far from corresponding to the universe of colleagues belonging to the Italian scientific sector AGRI-04/C Rural Buildings and Agro-Forest Land Planning. This is explained by the pilot nature of the questionnaire adopted in this survey. We drafted the questionnaire to minimize ambiguity and maximize clarity and answerability of the questions. We also appreciate the efficiency of the delivery mode, as the questionnaires have been completed in every aspect without missing or misinterpreted items. On the other side, in future work, we plan to apply validation techniques including data cleaning (by reverse coding negatively phrased questions), statistical analysis (with principal component analysis and Cronbach alfa test of consistency), and refining. Thereafter, we will be able to enlarge the number of complete questionnaires through cycles of invitations in a larger time. Validation would ensure a higher reliability of the data obtained through the questionnaire, while widening would fill the gap of statistical relevance of the whole exercise and of other specific issues, including the unbalanced representation of the working positions in favor of more executive roles (assistant professors). In the perspective of studying the worldwide attitude of agricultural engineers, the questionnaire can be submitted to an international audience through The European Society of Agricultural Engineers (https://eurageng.eu/) and the International Commission of Agricultural and Biosystems Engineering (https://cigr.org/). Secondly, the survey has been designed to obtain an instant picture of the attitude to innovating academic educational programs. The interviewee is introduced to the specific themes just with a brief paragraph (Appendix). Further work should be addressed to develop follow-up analyses including rounds of focus groups, dissemination strategies and mainstreaming measures. After this awareness rise, resulting pictures become more meaningful and operational.

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Questionnaire introduction.

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