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Perspective

Experiential learning in the context of BIM

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Abstract: BIM (Building Information Modeling) is conceived and understood differently depending on the profession and industry. As a technology, process or methodology, it is becoming an everyday part of the work of many engineers who deal with space. Hundreds of thousands of current and future representatives of the broadly defined construction industry (AECOO - Architecture, Engineering, Construction, Owner Operator), which accounts for about 1/10 of the GDP (Gross Domestic Product) of almost every country (including Poland), are educated in the formal education process in full-time, part-time, postgraduate or doctoral programs. BIM-related knowledge is imparted in various fields of study. Many publications mention the topic of BIM in education. However, they focus their attention on what to teach. This is undoubtedly very important, yet it is often forgotten how important it is to convey this knowledge.

I conducted an in-depth literature review of the content of teaching BIM theory and practice and the ways in which they are taught. My aim was to synthesize the latest trends in BIM didactics, present the latest methods and techniques for experiential learning and propose a conceptual framework for BIM education. The good practices presented in the paper can be used by a wide spectrum of teachers: university teachers, trainers or BIM managers. The previous form of monologue lectures must be abandoned in favor of interactive lectures that formulate problems. Labs or projects, on the other hand, should become a place for problem-solving and transcending the limitations posed by the maturity of BIM to date. The presenter should create a friendly learning space which, combined with skillful facilitation, will lead to creative concept generation, discovery or breaking through existing dogmas.

Keywords: engineering education, BIM, building information modeling, students, teaching content, experience

1. Introduction

The BIM (Building Information Modeling) literature is focusing its attention on what to teach. New BIM professions are emerging that force the learning of specific skills. College curricula are overflowing with the names of well-known BIM applications, yet students are not always able to operate the software they are learning. Employers complain not only about the lack of competence in design, but also in digital skills. Teachers - teachers and educators - are responsible for a large part of this problem. It is impossible to separate these two functions, especially in elite student education, where the master-student contact should be based on a sincere and respectful relationship. In English, there is a good term combining both functions - facilitation. In Poland, a facilitator is associated with a person who stands on the side of the process. Regardless of the function performed (facilitator, academic teacher, coach, tutor, mentor, etc.), an educator can and should combine the function of a person imparting knowledge and skills with a person shaping attitudes. In my experience as a university teacher (in Poland), but also previously as a student or doctoral student (at various levels of formal education), it seems that university teachers forget that they are role models for students - they present them with values, character, integrity and authenticity. Currently teachers consider it critical in the design of new learning environments to foster a collaborative and multidisciplinary school culture that emphasizes learners' wellbeing and inclusion, as well as utilizing readily-available digital instruments with basic-level functionality [1]. Often, institutional conditions are not much influenced by teachers, but they have a huge impact on psychological conditions. Collaboration and communication are at the heart of working in BIM. Therefore, creating a friendly learning space and with the right educator support will allow students to rise to higher and higher levels of maturity in BIM. The concept of experiential learning can be used in BIM education. The pillars of this idea can provide a framework for BIM education. Learning is the most important process of human adaptation. It accommodates other, more limited adaptive concepts such as the scientific method, creative processes, problem solving, decision making or attitude change [2]. Learning is associated with the school or university - the place where knowledge is transferred. The transfer of knowledge occurs from instructors to students. However, this approach limits both. When a teacher 'teaches', this transfer is usually one way. When a student 'learns' in the classroom, the transfer is two-way, to the benefit of both parties. The one-way transfer model of education does not seem to be waning, despite many studies and case studies that the so-called 'banking concept' (the all-knowing teacher passes on a piece of domain knowledge to the students) or the 'Prussian model' (dedicated, obedient and easily replaceable students listen to the only right authority) are not working. As a result, the majority of students still sit still hour after hour, day after day, week after week, year after year, and are expected to receive knowledge and then repeat and reproduce it. Jakubowski points out that the teacher should create what he calls a 'learning situation' in which people learn and are not taught [3]. They learn, i.e. they experience and elaborate this experience on an emotional and cognitive level. They are the subjects and at the same time the creators of their own activity. The teacher is of greatest importance in creating the learning situation. It is who he or she is, the relationships he or she enters into, what he or she can do and what he or she knows that gives the educational situation its fundamental expression. Therefore, education is an art and a true teacher a creator, in the deepest sense of the word [3].

Brain research shows that the four basic functions involved in learning are: feeling, remembering, theorizing and acting. The brain is primarily designed to solve problems [4]. In teaching, on the other hand, too much time and attention are given to memorizing and then recreating what is memorized. In the literature, there is a notion of "bulimic teaching," which involves stuffing the student with knowledge that is immediately "given back" after the exam, i.e., it does not remain in long-term memory [5]. Teachers of BIM-related subjects tend to have a much broader context in BIM, hence it seems to them that the student needs to know colloquially "this and that". In the early stages of learning a new discipline, the student is usually confronted with a lot of facts that are new to them. This information is often conceptually isolated for the student because, while an expert or teacher may perceive it as part of a schematic structure, the student is unlikely to automatically recognize such interconnections. Information assimilated at an early stage of learning is concrete rather than abstract and is linked to a specific context. In order for the student to understand the concept being presented, it is important that they experience it in concrete situations [6]. An example in BIM would be the concepts of data and information. When the presenter shows applications with concrete examples in the BIM model, the student will quickly understand both definitions and see the difference between the concepts mentioned.

In teaching, teachers focus on a concrete experience, which rarely culminates in reflection, experimentation or conceptualization. Some teachers forget that they are role models for students - they present them with values, beliefs and attitudes [7]. Thus, my aim was to extract the best-known learning methodologies, identify key learning tools and techniques and present them in the context of BIM teaching. The in-depth literature study focused more on the learning aspect than on the teaching content, which will continue to change as BIM continues to evolve.

2. Didactic content

Kurt Lewin's famous statement that there is nothing more practical than good theory, because there is no pure, theory-free 'practice' [8], should resonate strongly in the BIM world. BIM practitioners, in their hurried daily routine, sometimes forget that theory organizes, allows creation and discovery of the new. Constantly keeping up to date with the changing market enables one to maintain the competitive advantage that BIM has been giving for two decades. The practitioner should, and even must, adopt the latest technological solutions that make him or her more efficient and productive. On the other hand, theoreticians, even academics, by not confronting their theories with practice, may not keep up with trends or may lack a broader context. Because a concept acquires meaning and value precisely through its relationship to direct, subjective experience, universities often prefer the abstract and logical pole of the dialectic of cognition and pay little attention to the subjective experience of students. Even if the exercises or projects are practical, they are often based on the handing over of concrete materials or the performance of a case study, which ends with a certain result and often the only valid comment of the instructor.

The Knowledge, Skills, Attitude (KSA) model in BIM, which has been known for many years [9], covers different issues depending on the profession and industry. The state of the art of BIM is dynamically changing, and in 5 years' time, the topics listed here could undergo significant transformations. Definitions and concepts are constantly changing. Just look at how many definitions of BIM there are in the literature [10]. More letters are being added to the acronym BIM, e.g., HBIM [11], or existing letters are being replaced, e.g., LIM [12]. The field of BIM is becoming further complex with rapid, dynamic changes in the context leading to constant updates in the curriculum. Today, the ability to model or collaborate with industry is the basis of a so-called BIM modeler. The research depicts that while BIM platforms are increasingly being adopted by architectural and design firms, the evolution of these programs is far from complete, with more likely to follow [13]. On the other hand, applications based on Artificial Intelligence (AI) are already appearing that can build 3D models from 2D drawings. Thus, the teacher constantly has to keep an eye on knowledge-skills trends in order to impart the most up-to-date know-how possible and, at the same time, support students in shaping their attitudes. BIM can provide a means of enabling multidisciplinary learning and this applies to both engineering and architectural pedagogy [14]. A large quantitative study after keyword analysis identified several research trends, such as the need to integrate BIM at the program level by expanding from a single course e.g. quantitative surveying to integrating BIM with other digital technologies e.g. drone [15]. Another broad survey of the literature distinguishes six conceptual categories into which the efforts of BIM educators and researchers are grouped: (a) identification of BIM needs in higher education, (b) identification of necessary BIM skill sets for BIM education, (c) development of BIM educational frameworks, (d) development of BIM curricula, (e) experimentation with BIM courses and (f) development of strategies to overcome BIM educational problems [16]. The conceptual categories listed will be different for an architect, builder, surveyor or facilities manager. Research to date clearly demonstrates the need to teach BIM tools [17]. On the other hand, the multitude of abbreviations, acronyms or non-trivial terms can be confusing (Figure 1). It is important for faculty authorities and course coordinators to regularly review the needs of employers, analyze graduate profiles and make ongoing decisions about subjects, specializations, courses etc. [18]. Research results indicated that most architecture and construction schools either have an interest in or have already implemented BIM into their curriculum. The majority of the schools expected students to have a basic knowledge of BIM upon graduation, perceived BIM as important to industry and planned to fully integrate BIM into their curriculum [19].

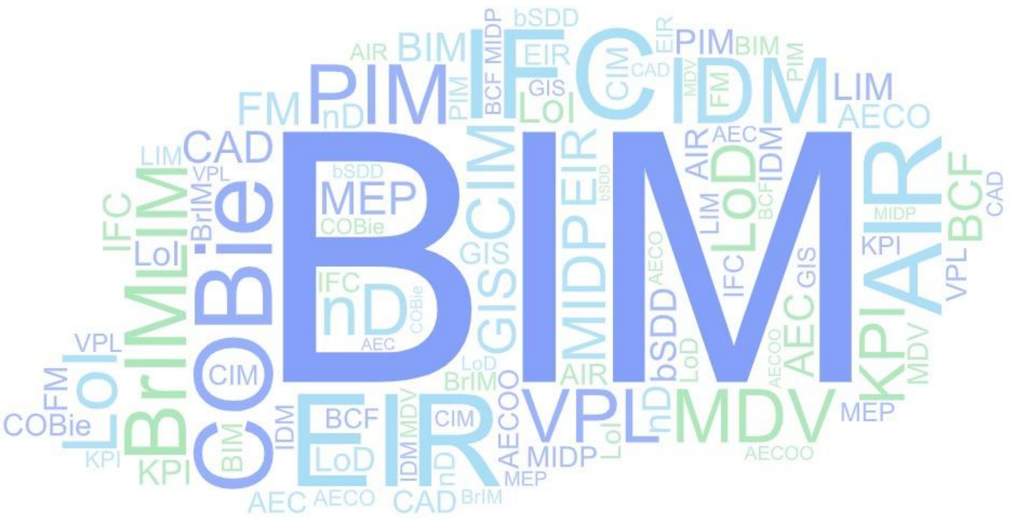

Figure 1. A tag cloud of BIM-related acronyms.

In Poland, the investment and construction process works are largely carried out by design firms (architectural and branch) and general contractors. Building management, together with the documentation and BIM models, is carried out by the owners and operators. These are the main stakeholder groups involved in the BIM process. The appropriate flow of resources depends on their activity (Figure 2). The BIM model should accompany the building throughout its life cycle, so the collaboration of these groups is essential [20]. From the earliest concept to detailed design, the work is done by design firms. Modeling and management knowledge and skills are used in this process. Interprofessional collaboration requires coordination, agreement and opinion skills to resolve issues (e.g., geometric clashes) arising from different design work. This is not easy due to, for example, the use of different IT solutions, where the structure of object ontologies in each program is different [21]. Thus, achieving interoperability is not easy [22]. Building a good BIM model enables the creation and generation of the various simulations (4D), statements (5D) and analyses (6D) necessary for construction work. The execution of the construction work should result in the relevant components of the BIM model (IFC – Industry Foundation Classes, AIM – Asset Information Model, COBie – Construction Operation Building information exchange) being passed on to the owners or operators. With such databases, they can further actively manage the facility, its resources and fixed assets (7D). Despite using BIM, which can have the mentioned advantages, there lies the risk that, at each of the mentioned stages, the BIM model can be abandoned in favor of flat documentation, which is not in line with the concept of BIM. This implies the listed construction activities must support the adoption of BIM throughout the building life cycle, which can only be achieved when stakeholders have received appropriate BIM education and are likely to support this process.

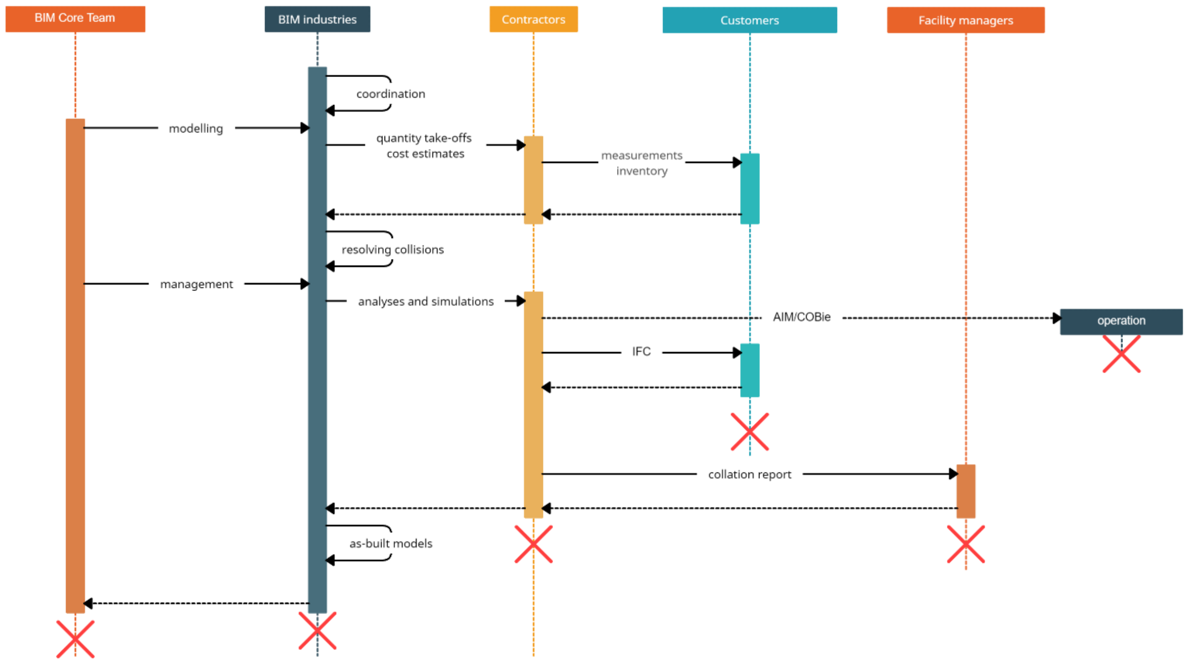

Figure 2. The fundamental flow of activity and resources in the BIM process.

The outlined flow can, of course, vary depending on the size, nature and circumstances of the investment in question. However, from this fundamental flow of activity and resources come certain principled skills and knowledge necessary for the BIM process. The data and information used from the BIM model give wisdom that, combined with the right attitudes (social skills), there is value to all participants in the investment and construction process. Each of the listed professions (BIM Coordinator, BIM Modeler, BIM Technician, etc.) must possess certain knowledge, skills and exhibit certain attitudes. Especially the latter are extremely important in today's dynamic times requiring rapid adaptation. In addition to the previously mentioned skills in modeling, management, coordination, skills in communication, process automation or problem solving should be mentioned [23]. Specific skills such as component modeling, organizing libraries or visual programming will change over time as AI develops. Hence, a BIM teaching framework is presented in Figure 3. While this does not finitely list all items, following the framework in teaching BIM can positively change BIM education status. This holistic approach can positively affect students and support their learning process.

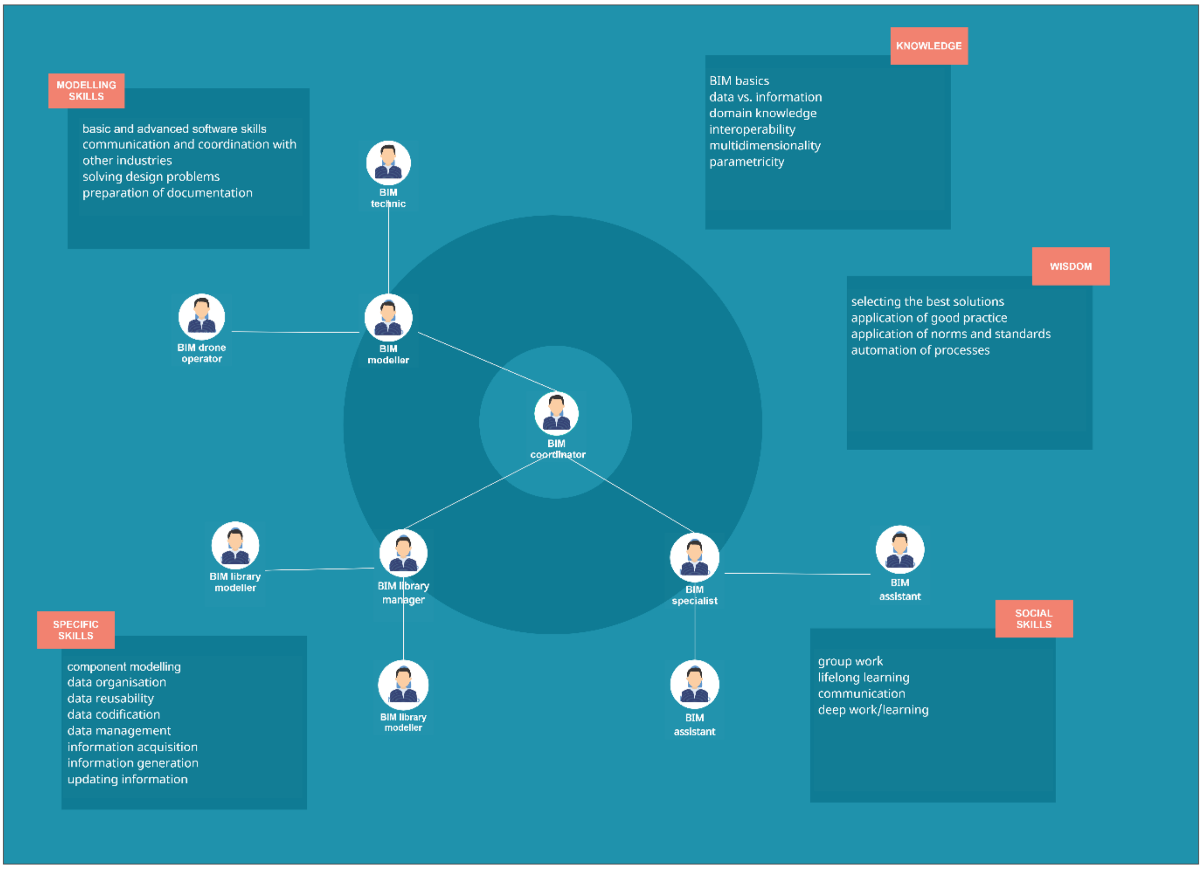

Figure 3. Conceptual framework for teaching BIM – a holistic approach that takes into account various aspects.

During exercises or projects, it is worthwhile to take care of non-homogeneous groups and to be as diverse and inclusive as possible. Many studies show that such groups record better outcome rates than their homogeneous counterparts [24]. If an educator is delivering content based on instruction, he or she should not give it to the student until after the class is over. Giving instructions or recordings too early can undermine motivation for further learning at the start. Employer requirements in terms of knowledge and skills will continue to change. However, the attitudes that are required of potential employees will probably remain the same: these are assertiveness, self-awareness, attentiveness, etc. Furthermore, the teacher should encourage his or her students to read books and keep learning. In BIM, well-known items such as [25] or [26] may open the list of items. Tutoring books for learning the software will help students to master the tools well, even if class time has prevented the transfer of all skills. In addition to presenting all items in the first class or including them in the syllabus, it is good practice to bring them to class (Figure 4). Reading books in BIM can be even more important than reflecting on personal experience, as it broadens possibilities and perspectives. Second-hand knowledge is more generalized and can go beyond what is known from experience. Education is measured by the extent to which it allows all people to access the objective content of thought, theoretical systems, issues and ideas whose implications are not yet known [27]. Students should be influenced by the literature on the subject [6]. If, in the course of class or further training outside of class, a student notices an interesting bibliographic item, they should be encouraged by the instructor to share their personal experience. If both find it worthwhile to introduce the item into the syllabus, it is worth doing so. The teacher can send students links or pdfs of academic articles to read for those who are willing. This kind of optionality very often works proactively when the student knows that he or she has the right to learn rather than being forced to learn. BIM projects should help students connect their learning at university with their out-of-school experiences and undergo transformative experiences. Such projects can support deeper learning and identification of future careers [28].

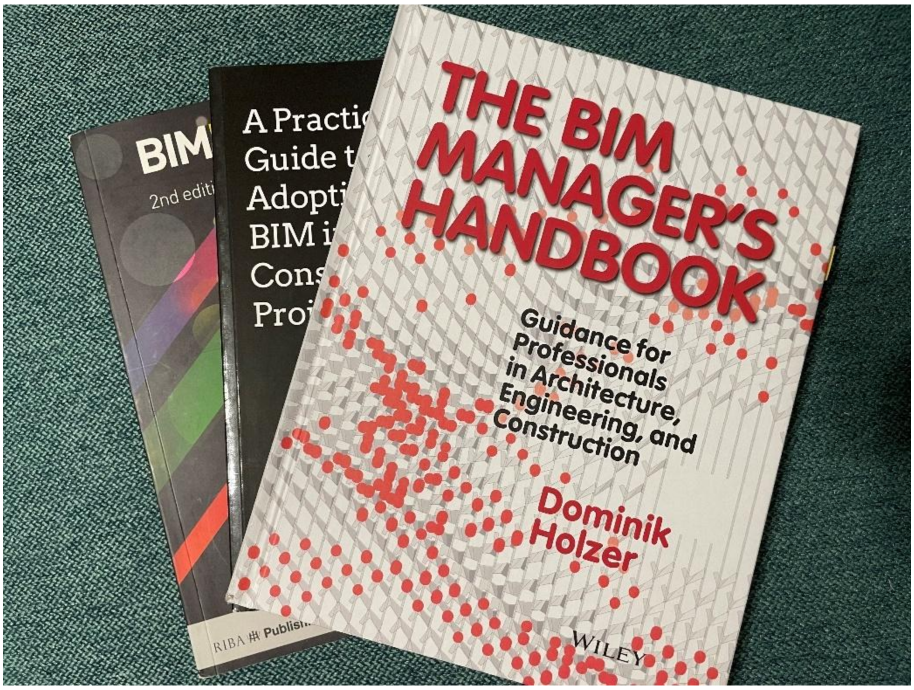

Figure 4. Examples of BIM books brought to class.

The student should be motivated to ascend to higher and higher levels of sophistication, up to an anticipated noetic level that can lead to ecstatic satisfaction. If the student becomes sufficiently interested in the subject, they will dig further and explore the threads that intrigue them. As a result of reflection, subsequent creation and discovery, they may fall into a so-called learning spiral that will lead them deeper and deeper. Over time, they will perhaps question the dogmas they have previously had instilled, even by outstanding and inspiring teachers. In order for learning to occur at higher levels, the knowledge that the student has acquired must be placed in a supra-individual repository so that others can access it. Hence, it is worth encouraging students to publish their work or research results. Concepts and design work can freely become a popular science article presented on industry portals, and interesting research results can be published in a scientific journal. The prestige of the journal in this case does not matter, it is about showing the student that they have the opportunity to create and give value to others.

3. Experiential learning

Piaget noted that children construct their cognitive world through two distinct yet inextricably linked adaptive processes: accommodation and assimilation [29]. Assimilation occurs when new a experience is incorporated into previously held knowledge. Accommodating occurs when an individual structurally adapts to newly acquired information. Very often these occur simultaneously or immediately after each other. Assimilation in BIM often refers to acquired skills, e.g. in the use of software. Accommodating, on the other hand, can lead to a change in behavior when, for example, a new concept or rule of action is discovered. Whatever the circumstances, a person acquires new knowledge or skills at the same time as shaping their attitudes. This leads to a development that has no end.

Experience-based learning, often referred to as Kolb’s cycle, is based on two dialectically correlated modes of experience capture: Concrete Experience and Abstract Conceptualization, and two correlated modes of transforming experience: Reflective Observation and Active Experimentation. Using all modes, building and resolving tensions between them, results in learner development. Bandura, on the other hand, argues that learning can also occur by simply observing. It occurs in four steps: (i) directing attention to the observed behavior, (ii) remembering that behavior, (iii) being able to repeat, bringing it up on its own, (iv) being motivated to have the behavior repeated [30]. The student, during BIM lectures, often observes how a particular process, e.g., stakeholder collaboration, occurs and perhaps repeats it in the future, if necessary. Students can be encouraged to practice a particular process by sending an instructional video or a step-by-step "manual". Not all topics can be covered in class, those that are time-consuming or go beyond the program can be signaled and encouraged to be studied on their own. In class, it is worth encouraging students, not to take notes but to make association maps or graphs, which increase the efficiency of the learning process [31].

By combining our experiences, as richer human beings, we enter into a new experience, we give ourselves again and always rise above our former selves through giving. It is most difficult to record experiences in long-term memory, but if successful, they can easily be replayed during ongoing challenges or planned activities. The teacher should provide a kind of 'scaffolding' for the student. The scaffolding strategy essentially involves the educator controlling those parts of the task that are initially beyond the student's ability, allowing the student to focus on those parts that are within their competence. A successfully completed task generates a desire to continue it or to set further goals [32]. In BIM, a section of the class may be devoted to modeling a particular structure, and then it should be hinted that higher competencies will be required for another structure. Such a suggestion encourages further exploration of the subject.

3.1. Friendly learning environment

An effective learning process can only take place in a friendly space. In his publications, David Kolb lists the factors that influence the creation of a so-called friendly learning space: the place, the psychological state of the learners, the instructor-student relationship, institutional conditions or time constraints [2]. Among the dimensions of the learning space, he mentions: psychological, social, institutional, cultural and physical dimensions. Each dimension is influenced - more or less - by the teacher. Just as he or she may have less influence on time constraints or standards of classroom equipment, the relationship that develops between him or her and the student has a huge impact. In BIM teaching, the teacher builds his or her authority not only through his or her extensive knowledge, beyond a certain framework, but also through his or her kindness or authenticity.

The basic conditions for creating a friendly learning space are psychological safety, a meaningful purpose and mutual respect. In psychological safety, the student must be assured that he or she has the right to learn, has the right to voice his or her opinions, to change them and to express emotions. At teacher conferences, one often hears "Maslow before Bloom" (Maslow's pyramid of needs before Bloom's taxonomy) - that is, there should be psychological safety before any teaching. Psychological safety is not about being nice or lowering standards. On the contrary, it is about recognizing that high performance requires openness, flexibility and interdependence, which can only be developed in a safe environment. Unconditional respect, which the tutor should express from the first meeting, builds an atmosphere of trust and develops opportunities for collaboration. In a teacher's job, it is beneficial to greet students with courtesy and with attention to each individual. The easiest way to show interest in students is to know their names and use them in class. Rogers points out that showing unconditional respect to everyone is extremely difficult, but remains crucial to promoting positive change and development [33]. It is not about tolerance, i.e., acquiescence or patient endurance, it is about accepting everyone as they are. Unfortunately, a large proportion of teachers instead use conditional respect, shown when a student meets expectations or achieves excellent results [34]. Conditional respect encourages students to show only the most favorable face while hiding weaknesses and mistakes. Respect, on the other hand, should be shown always and everywhere regardless of the circumstances. The so-called learning-from-mistakes culture developed, for example, in the Scandinavian countries, shows that everyone has the right to make mistakes, the important thing is to learn from them and improve one’s actions or behavior.

The essential purpose of the class creates a desire to explore and learn new things. The educator should set high standards and challenging learning goals. However, in the end, it is the learner who has to decide to take up the challenge. He or she cannot be forced to do so. BIM is easy to get interested in, the advantages and benefits of using it are many. It will be more difficult to convince the student that it is a good way forward, especially as there are many limitations in BIM, as well as risks and dangers arising from it. The learning objectives set by the teacher should be clear, overt, ambitious and should go beyond just learning the details of a subject. Certainly one objective is to impart accumulated domain knowledge (e.g. architectural design in BIM), but such an objective may also be to formulate problems that are currently occurring in the subject. Such signaling of important problems will enable the development of in-depth inquiry skills and refine reasoning abilities. The teacher can also set supportive goals such as: building and sustaining learning motivation or maintaining optimal energy levels in the group [35].

3.2. Conscious training

Chen, Darst and Pangrazi developed a situational interest scale that identifies 5 dimensions: novelty, challenge, willingness to explore, immediate enjoyment and enforcement of attention [36].

In teaching BIM, the so-called tutoring or 3P method (tell, show, practice) is often used to teach the use of design software. Well-conducted training of this kind can satisfy the first dimension mentioned: novelty. As a rule, students enthusiastically take in the content and eagerly repeat the activities because they know they are concrete skills. Such a process is called conscious training. In contrast, to instill in a student the desire to explore a topic further, a challenge needs to be set. This can be homework. It is important that it is work for the willing – optional. By forcing the exploration of a topic that has not interested the student, the student may only be discouraged from the problem posed. There are now already major studies by researchers from Denmark, the UK and the USA which demonstrate that compulsory homework is counter-productive and hinders, rather than promotes, academic progress [37]. On the other hand, when such optional homework is assigned, it is good to set a reward right away, e.g. a plus for activity. In education, there should be no minus or other forms of punishment for inactivity, as it may be due to various reasons, unknown even to the teacher. Instead of grades, activity marking (e.g., the aforementioned plus) should be used, and prompt feedback should be given. Feedback, in turn, should be full, concise, kind and not refer to judging the student's commitment [6]. If the student rises to the challenge and faces it, it is very possible to keep his or her attention and set more difficult challenges.

Developing intellectual capacity in students should be based on structured as well as unstructured problems [38]. Structured problems can be described with considerable accuracy and certainty, and experts will agree on their solution. Such tasks in BIM are easily formulated by pointing to a selected aspect of modeling (plant design) or analysis (obscuration analysis) of a particular development. Unstructured problems cannot be described in this way and experts will argue about how to solve them. In BIM, an example would be integration with GIS (Geographic Information Systems), which is considered at different levels (application or database) and in different dimensions (2D, 3D). For unstructured problems, the aim is to learn how to construct rational solutions and defend them. During projects or exercises, it is useful to use structured discussion in small groups to create a space for students to explore their own and others' ideas.

An Interesting tool used by Kolb and his students is the so-called flipped lesson [2]. This is a lesson in which the teacher turns into a student and the student turns into a teacher. Before such a flipped lesson, the teacher suggests what the topic of the next lesson will be and indicates that it is up to the students to master the topic and show the teacher how to do the activity correctly. In BIM, this could be a selected aspect of the designer's work, e.g., preparing a sheet with a particular piece of documentation for printing. As students prepare for the flipped lesson, they explore the given topic and try to meet the challenge. Whether they succeed in doing it well is of secondary importance. What matters is the creative activity itself and perhaps a momentary reflection that teaching from a teacher's perspective is not so simple after all.

3.3. Teaching through conversation

The more genuine the conversation, the less its conduct depends on the participants. A genuine conversation can lead to learning on both sides - teacher and student. Reflection and logic are often included in the conversation. This results in a discourse that turns into activism. Both parties want to act. Without conversation, conducting a monologue e.g., during a lecture deprives one of the opportunity to learn as a leader. It becomes increasingly difficult for non-activated students to remain attentive. Yes, the lecture will always remain the educator's field of action for the most part, but even asking reflective, challenging questions can completely change the learning process. Questions are a very good learning tool that activates the student and encourages them to test the validity of the hypotheses they articulate. Simple techniques, e.g., a 5 second pause after asking a question, can significantly increase interactivity, compared to a 1 second pause [39]. The best reflective questions will be those to which there is no good, straightforward answer e.g. "Is BIM a technology, a process or a methodology?".

Both in lectures and in exercise or project classes, so-called deep learning can be initiated, which is the opposite of so-called surface learning. Deep learning can only arise during heated discussions and subsequent reflection. During group discussions, it is sometimes useful to let go of control and let the students choose the topic and direction of the discussions themselves. In such cases, it often turns out that they choose wisely and meaningfully.

4. Discussion

The most profound self-realization is to find one's own path involving continuous learning and this is the direction in which the student should move, with the help of a conscious educator. By building a friendly learning space, the educator facilitates the use of various teaching tools and techniques, including conscious coaching and conversational learning. Using these supports the student experiencing without hiding their emotions and insights. As a result, he or she actively shares them with the group, activating the processes responsible for reflection and abstraction in themselves. This in turn leads to deep learning that results in discovery and creation (Figure 5) because it is discovery and creation that are responsible for the learner's satisfaction and personal development.

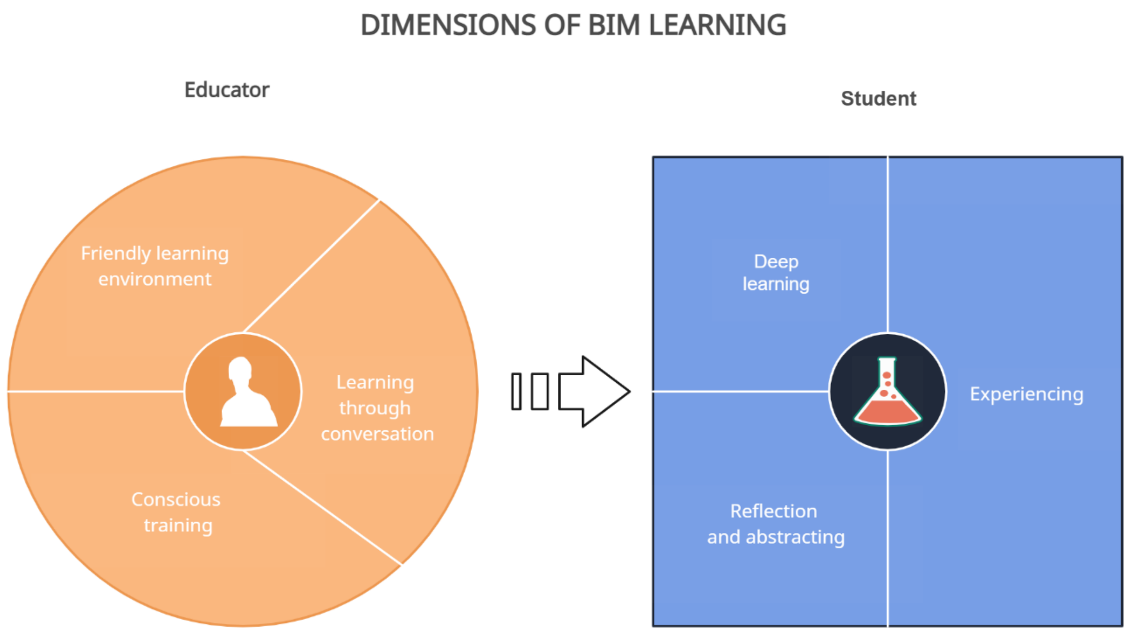

Figure 5. Dimensions of BIM learning.

Designed classes with BIM topics should focus on the development of competence in writing, verbal communication and critical thinking skills while respecting the ethics of learning. There needs to be a deliberate focus on teaching the development of innovative thinking and problem solving by students in the context of discipline-based curricula. This approach is often avoided by educators due to the significant volume of discipline-specific knowledge to be taught and the difficulty for educators to integrate competencies into the engineering [40]. The educator, in turn, should be aware of all forms of expression of students' mental states - puzzlement, boredom, fluency, emergence of new ideas, feigned attention, and so on. He or she should respond to them maturely with respect for teaching. In the presence of a sensitive and empathetic teacher, students take responsibility for their own performance, charting their individual path of development. Thus, the most effective learning will be the learning that flows from their own desire to learn. The environment created and provided by the educator will positively influence the student, who, becoming self-taught, will continue his or her education throughout life [41].

5. Conclusions

Conventional assessment of student achievement has historically focused on the reproduction of factual and procedural knowledge with a particular emphasis on fact-finding and the application of routine formulas and procedures. In contrast, the concept of experiential learning allows students to develop higher-order thinking by solving real-world problems rather than assimilating facts and reproducing instructions. The ubiquitous concept of assessing students and dividing them into winners and losers should give way to the empathetic, respectful and supportive idea of educator-student collaboration. Through a friendly learning space, both educators and students learn as they ascend to higher and higher levels of proficiency. The proposed BIM learning conceptual framework can assist teachers in the teaching process. Teaching BIM is not easy, but it can give plenty of satisfaction to both parties if they recognize that the synergy of their joint efforts can lead to discovery and creation.

Use of AI tools declaration

I declare that I have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

I declare no conflicts of interest in this paper.

Ethics declaration

I declare that no ethics approval is required for the study.

References

1. Sarkio, K., Korhonen, T. and Hakkarainen, K., Tracing teachers' perceptions of entanglement of digitally-mediated educational activities and learning environments: a practice-oriented method. *Learning Environments Research*, 2023, 26(2): 469–489. https://doi.org/10.1007/s10984-022-09442-w
2. Kolb, A. and Kolb, D., *The Experiential Educator, Principles and Practices of Experiential*

Learning, 2017, Experience Based Learning System Inc.
3. Jakubowski, J., *The learning situation*, 2022, Warsaw, Poland: TROP Group. (in Polish)
4. Hüther, G., *Who are we - and who could we be?*, 2015, Literature Inspires Publishing Group.
5. Zorek, J.A., Sprague, J.E. and Popovich, N.G., Bulimic learning. *American Journal of Pharmaceutical Education*, 2010, 74(8): 157.
6. Hosseini, M.R., Khosrowshahi, F., Aibinu, A. and Abrishami, S., *BIM Teaching and Learning Handbook: Implementation for Students and Educators*, 2022, New York, USA: Routledge.
7. McCabe, D.L. and Trevino, L.K., Cheating among business students: A challenge for business leaders and educators. *Journal of Management Education*, 1995, 19(2): 205–218.
8. Lewin, K., *Field Theory in Social Sciences*, 1951, New York, USA: Harper & Row.
9. Banathy, B., *Instructional Systems*, 1968, Palo Alto, USA: Fearon Publishers.
10. Doan, D., Ghaffarianhoseini, A., Naismith, N., Zhang, T. and Tookey, T.,What is BIM?: a need for a unique BIM definition. *IConBEE2018: Inaugural International Conference on the Built Environment and Engineering*, 2019, 88. Retrieved from: https://www.researchbank.ac.nz/handle/10652/4572
11. Ramirez Eudave, R. and Ferreira, T.M., On the suitability of a unified GIS-BIM-HBIM framework for cataloguing and assessing vulnerability in Historic Urban Landscapes: A critical review. *International Journal of Geographical Information Science*, 2021, 35(10): 2047–2077.
12. Borkowski, A. and Łuczkiewicz, N., Landscape Information Model (LIM): a case study of Ołtarzew Park in Ożarów Mazowiecki municipality. *Budownictwo i Architektura*, 2023, 22(2): 41–56. http://dx.doi.org/10.35784/bud-arch.3547
13. Huber, A.M., Waxman, L.K. and Dyar, C., Using systems thinking to understand the evolving role of technology in the design process. *International Journal of Technology and Design Education*, 2020, (32): 447–477. https://doi.org/10.1007/s10798-020-09590-1
14. Oliveira, S., Olsen, L., Malki-Epshtein, L., Mumovic D., D'Ayala D., Transcending disciplines in architecture, structural and building services engineering: a new multidisciplinary educational approach. *International Journal of Technology and Design Education*, 2022, (32): 1247–1265. https://doi.org/10.1007/s10798-020-09645-3
15. Wang, L., Huang, M., Zhang, X., Jin, R. and Yang, T., Review of BIM Adoption in the Higher Education of AEC Disciplines. *Journal of Civil Engineering Education*, 2020, 146(3): 06020001. https://doi.org/10.1061/(asce)ei.2643-9115.0000018
16. Chegu, B.A., Chang, Y-T. and Hsieh, S.Y., A review of tertiary BIM education for advanced engineering communication with visualization. *Visualization in Engineering*, 2016, 4(1): 1–17. https://doi.org/10.1186/s40327-016-0038-6
17. Suwal, S. and Singh, V., Assessing students' sentiments towards the use of a Building Information Modelling (BIM) learning platform in a construction project management course. *European Journal of Engineering Education*, 2018, 43(4): 492–506. https://doi.org/10.1080/03043797.2017.1287667
18. Waszkiewicz, M., BIM education project in the new educational concept of the Faculty of Management at Warsaw University of Technology. *Studies and Papers of the College of Management and Finance*, 2018, (159): 207–227.
19. Smith, W.N., Smith, J. and Bingham, E.D., Current State of Practice Associated with the Use

of Building Information Modeling (BIM) in the Custom Home Building Industry. *International Journal of Construction Education and Research*, 2022, 18(3): 251–269. https://doi.org/10.1080/15578771.2011.632809

20. Zhao, D., McCoy, A.P, Bulbul, T., Fiori, Ch. and Nikkhoo, P., Building Collaborative Construction Skills through BIM-integrated Learning Environment. *International Journal of Construction Education and Research*, 2015, 11(2): 97–120. https://doi.org/10.1080/15578771.2014.986251
21. Esser, S., Vilgertshofer, S., Borrmann, A., A reference framework enabling temporal scalability of object-based synchronization in BIM Level 3 systems, European Conference on Computing in Construction, *40th International CIB W78 Conference*, 2023, Heraklion, Crete, Greece, July 10-12, 2023.
22. Turk, Ž., Interoperability in construction–Mission impossible?. *Developments in the Built Environment*, 2020, 4: 100018. https://doi.org/10.1016/j.dibe.2020.100018
23. McCrum, D.P., Evaluation of creative problem-solving abilities in undergraduate structural engineers through interdisciplinary problem-based learning. *European Journal of Engineering Education*, 2017, 42(6): 684–700. https://doi.org/10.1080/03043797.2016.1216089
24. Kayes, D.C., Experimental Learning in Teams: A Study in Learning Style, Group Process and Integrative Complexity in Ad Hoc Groups. *PhD thesis*, 2001, Case Western Reverse University.
25. Eastman, C.M., *BIM Handbook: A Guide to Building Information Modeling for Owner, Manager, Designer, Engineers and Contractors*, 2011, John Wiley & Sons.
26. Holzer, D., *The BIM Manager's Handbook - Guidance for Professionals in Architecture, Engineering and Construction*, 2016, John Wiley & Sons Inc.
27. March, J.G., *Toward the Essence of Adult Experimental Learning*, 2010, Jyvaslyla, Finland: SoPhi.
28. Pugh, K.J., Kriescher, D.P., Tocco, A.J., Olson, C., Bergstrom, C.M., Younis, M., et al., The Seeing Science Project: Using Design-Based Research to Develop a Transformative Experience Intervention. *Journal of Science Education and Technology*, 2023, 32(3), 338–354. https://doi.org/10.1007/s10956-023-10031-6
29. Piaget, J., *Play, Dreams and Imitation in Childhood*, 1962, New York, USA: W.W. Norton.
30. Bandura, A., *Social Learning Theory*, 2007, transl. Radzicki J., Kowalczewska J. Warsaw, Poland: PWN. (in Polish)
31. Zucker, A., Kay, R. and Staudt, C., Helping Students Make Sense of Graphs: An Experimental Trial of SmartGraphs Software. *Journal of Science Education and Technology*, 2014, 23: 441–457. https://doi.org/10.1007/s10956-013-9475-3
32. Bruner, J.S., *Actual Minds. Possible Worlds*, 1986, Cambridge, UK: Harvard University Press.
33. Rogers, C., *On becoming oneself*, 2000, Translated by Karpinski M. Poznań, Poland: Rebis. (in Polish)
34. Abdullah, A.Ç.A.R. and Yüksel, S., Examining Prospective Teachers' Ideological Beliefs and Preparation for Diversity. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, 2022, 35(2): 314–338.
35. Matras, J., Żak, R., *Coach in leading roles*, 2018, Warsaw, Poland: PWN. (in Polish)

36. Chen, A., Darst, P.W. and Pangrazi, R.P., What Constitutes Situational Interest? Validating a Construct in Physical Education. *Measurement in Physical Education and Exercise Science*, 1999, 3(3): 157–180.
37. Jull, J., *School crisis*, 2014, Kraków, Poland: MiND Publishing House. (in Polish)
38. King, P. and Kitchner, K., *Developing Reflective Judgement*, 1994, San Francisco, USA: Jossey-Bass.
39. Rowe, M.B., Pausing Phenomena: Influence of the Quality of Instruction. *Journal of Psycholinguistic Research*, 1974, 3(3): 203–224.
40. Ovbiagbonhia, A.R., Kollöffel, B. and Brok, P.D., Educating for innovation: students' perceptions of the learning environment and of their own innovation competence. *Learning Environments Research*, 2019, 22: 387–407. https://doi.org/10.1007/s10984-019-09280-3
41. Dryden, G. and Vos, J., *Revolution in Learning*, 2022, Poznań, Poland: Zysk i S-ka Wydawnictwo. (in Polish)

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