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A Blended Approach to Inquiry-Based Learning Using the Example of the Interdisciplinary Course of BIM in Spatial Management Studies: A Perspective of Students and Professor

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Abstract: Inquiry-based learning (IBL) is one of the most effective teaching methods to follow the trend of constructivism. Its main premise is the dominant role of the cognitively activated student, who, like the researcher, has the opportunity to pose questions, test hypotheses and solve problems by using a wide range of tools and techniques. The output of the IBL method is usually a presentation or a piece of work. In the experiment carried out, the IBL method was used during the interdisciplinary course "Building Information Modelling (BIM)", taught at the master's degree programme majoring in spatial management at the Warsaw University of Technology. The aim of the class was to solve a specific problem and develop a scientific and technical manuscript, which at the same time could form the basis of a scientific publication. The class was first experimentally implemented with a mixed-methods approach based mainly on IBL. Students were introduced to IBL techniques and tools as part of a project exercise, then were presented with problem and research topics. Participants in the classes chose an issue from those presented or created a topic of interest themselves. Peer learning, Montessori silent lessons or supervision were used during the implementation of the activities. Students were not assessed digitally, but their activity was marked in the form of pluses (+) and the focus was on providing quick and complete feedback (always individually to the individual or group). The class concluded with a self-assessment and a research questionnaire, which concluded that an authoritative teaching process was a far better choice than an authoritarian or liberal process.

Keywords: inquiry-based learning; BIM; building information modelling; peer learning; feedback

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1. Introduction

Inquiry-based learning is a method based on questioning and inquiry; at the same time it is an approach to teaching and learning that places students at the centre of the learning experience [1]. Teachers, in turn, create an environment where young people's ideas are developed and treated with respect [2]. In this model, the idea is that students become responsible for engaging in learning and developing their own skills and knowledge [3]. This makes them caring, motivated, collaborative and innovative [4]. Teachers play an active role throughout the process, creating an environment where students' ideas are supported and treated with respect [5].

Together, teachers and students are the authors of the learning experience [6]. They accept mutual responsibility for planning, assessment and individual and group progress [7]. One of the great challenges in inquiry-based learning is getting students used to coming to a solution to a problem/task on their own [8]. Here, systematic reasoning takes the place of momentary curiosity [9]. The teacher plays the role of a provocateur who looks for creative ways to present topics to students so as to engage the individual or group in an ongoing search and exploration of the issue being learned [10]. The result is a regular discussion of peer learning [11]. By learning about the perspectives of others, students better understand their own positions and seek to justify them accurately [12].

All students can contribute to a joint investigation [13]. For example, some ask questions and explain them to other students, while the rest answer and explain or combine all opinions into a whole [14]. Teaching through inquiry includes but is not limited to: having open discussions [15]; working in groups/pairs [16]; sharing knowledge [17]; explaining new issues; expressing one's opinion, seeking and selecting information [18], using previously acquired knowledge and combining it with new knowledge; critical thinking [19]; sketching; mind maps [20]; posters; and projects [21]. Students' ideas, expressed in many forms, are used to deepen their understanding of the topic and to ask questions and spot issues that students want to learn more about. Spontaneous questions are a sign of genuine curiosity [22].

In other teaching methods, such as challenge-based learning (CBL) or problem-based learning (PBL), there is a wide spectrum of tools that could also be applicable to the IBL method. For example, PBL is an attractive, promising but also challenging, educational approach for both students and teachers [23]. To address the challenges, one of the most popular strategies proposed is to build educational scaffolds that gradually help students to successfully solve the subproblems and tasks that arise [24]. The problem-solving approach, the scaffolding method, supervision, and many, many other techniques can also be applied in IBL. Hence, the aim of this research was to find out whether a mixed-methods approach, incorporating different tools and techniques, could yield even greater benefits than, for example, a project-only approach. A survey questionnaire was administered to students at the end of the class to investigate their satisfaction with this form of teaching. The experimental classes were conducted as part of the course entitled 'Building Information Modelling (BIM)', which is implemented in the interdisciplinary course of study, Spatial Management, at the Warsaw University of Technology, Poland. The study programme for this major includes content from various industries and disciplines, and the graduate can find his or her way into many areas of social and economic life. BIM itself is one of the many technologies, along with CAD (Computer Aided Design), GIS (Geographic Information System), LiDAR (Light Detection and Ranging) or AI (Artificial Intelligence), that are applied in the course of study. These technologies are used in a wide range of activities by urban planners, e.g., in the development of maps [25], variants [26], analyses [27], simulations [28] or designs [29]. BIM can be considered from two perspectives—a broader and a narrower one. BIM sensu largo is a process based on the collaboration of people, information systems, databases and software. In a much broader sense, it can also include hardware, tangible and intangible resources, or knowledge. BIM sensu stricto is a semantic database of the construction object accompanying it throughout its life cycle [30]. The organization buildingSMART, which disseminates and promotes BIM, provides a similar definition: "BIM is a collaborative way of working underpinned by digital technologies, which allow for more efficient methods of designing, delivering, and maintaining physical built assets throughout their entire lifecycle". BIM is still a maturing technology, hence there are many challenges and limitations in it that were suitable as research topics for the students. The groups that selected the problem topics proved to be remarkably effective, and it was decided that six mature manuscripts would be published as scientific articles.

2. Materials and Methods

Classes in the form of exercises in the subject "Building Information Modelling (BIM)" were carried out as part of the Master's degree programme (3 ECTS) in Spatial Management from 4 October 2023 to 25 January 2024. This was the second year of the experiment with the IBL method. In previous years, the course was conducted using the unified project method for all participants. The student's hourly workload remained unchanged; however, the formula for classes was completely restructured. The experimental classes were attended by 29 students divided into two practice groups (group No. 1–15 students, group No. 2–14 students). These are the classic participant sizes for so-called project groups for practical classes held in Poland. The study group included 17 women and 12 men of similar ages. No sensitive data other than basic personal information were collected. The class cycle consisted of 15 weekly exercises and accompanying lectures. During the first class, in addition to the standard organisational content, the idea of the IBL and potential research topics were presented. The lecturer stipulated that the topics presented were not limited and that one could create one's own problem topics. However, each time, the student or group following their interests were to keep in mind that the topic must be related to BIM in some way, at least minimally. The paradigm of these classes is based on the fact that there is no rigid framework, and regulations can stand in the way of innovations and breakthroughs, which is not to say that there are no rules. They were set at the beginning of the class between the professor and the students. In the second class, the presentation of the learning process and the tools and techniques of constructivism continued. In the third class, individual discussions were held on students' interests. The instructor encouraged them to choose a topic after having researched it (orientation). At the same time, the teacher emphasized that, during the class, he would give feedback and not put a grade in the form of numbers. The students began to organise themselves into groups or undertake the topic independently. Some individuals or teams chose from the topics presented to them; others decided to pursue their own idea that was set in the context of BIM (Table 1).

Table 1. Research topics (topics selected by students are in bold and italicised).

Lp.	Topics Suggested by the Teacher	Student-Created Themes
1.	Proposal for an internal BIM audit for a selected organisation	***Application of BIM in the context of conceptual urban design***
2.	***Multiple use of data—rivers of data***	***Overview of modern teaching methodologies in the context of BIM***
3.	Good practices, best practices, next practices in BIM	***Conversion of BIM data into GIS using FME***
4.	Experience-based BIM education	***From BIM to GIS using geoJSON***
5.	***Development of a BIM placemat for any company***	
6.	***From linear to circular economy in the context of BIM***	
7.	***Counting the carbon footprint in scope 3 (scope 3) e.g., at sub-suppliers (adding the result to the invoice)***	
8.	***Netographic study (role of social media in BIM)***	
9.	BIMscript 3.0 for Rhinoceros	
10.	Survey Information Model (SIM) for BIM	
11.	Rhynamo/Dynamo for Revit	
12.	The problem of securing families (.rfa) and dynamo scripts (.dyn)	
13.	BIM "bypasses" any constraint using "tool ecology"	
14.	BIM Master File—content (e.g., in 3 applications)	
15.	Datastorytelling (Revit + PowerBi) in some context e.g., Bosch video surveillance	
16.	Combining IoT sensors with BIM (maturity level 3b or 3c)	
17.	***Linking RFID with BIM, e.g., in the context of access to different parts of a building or site***	
18.	Ways to secure the 3 layers of IoT: physical, application and network	

Topics ranged from quasi-theoretical to engineering/technical topics. This was to show that research could be both fundamental and applied. Once a topic had been selected, individuals or teams started working on their topics. As a rule, the first stage was topic orientation, conceptualisation and a literature review. After the mentioned stages, students started to experiment, test or shape the form of the final paper. The instructor in class 4 introduced the structure of a research paper, the popular concept of IMRaD [31] and explained how to conduct research. The next two exercises (classes 5 and 6) were devoted to thematic consultations—the so-called Montessori silence lessons [32]. Each person or group had the opportunity to present their initial efforts and discuss their ideas with the instructor. Classes 7 and 8 were dedicated to peer learning [33]. Each individual and each team was required to present the results of their work so far to obtain feedback from the presenter and the group. Prior to the peer learning, presenters (willing individuals or groups) and reviewers were appointed for each presentation. Thus, feedback was provided not only by the presenter but also by the peer(s). The subsequent classes 9, 10, 11 were again devoted to consultation (Montessori silence lessons) and, in the case of advanced projects, to supervision. The advantages of supervision in developing higher-order competencies have been proven many times [34]. Individuals or groups have already submitted a first manuscript form, which has been subjected to careful analysis and reflection. Exercises 12 and 13 were set aside for a second round of peer learning. Reviewers were again appointed, who were generally different to those reviewing in the first round. High-quality feedback was appreciated from the instructor, who marked the student activity as a plus (+). The penultimate class (No. 14) was devoted to final consultation, supervision and editing of the manuscript content. Final versions of the paper were uploaded to a network drive a few days before the last class. The students' papers were reviewed by the instructor and 6 of them were selected as being of outstanding scientific quality to contribute to a future publication. In the last class, a self-assessment, a research survey on the form of the exercise class and a discussion were conducted. The research survey was preceded by the collection of voluntary consents to participate in the survey and the publication of the results in a pseudo-previewed form. The progression of the classes and research is shown in the flow chart (Figure 1).

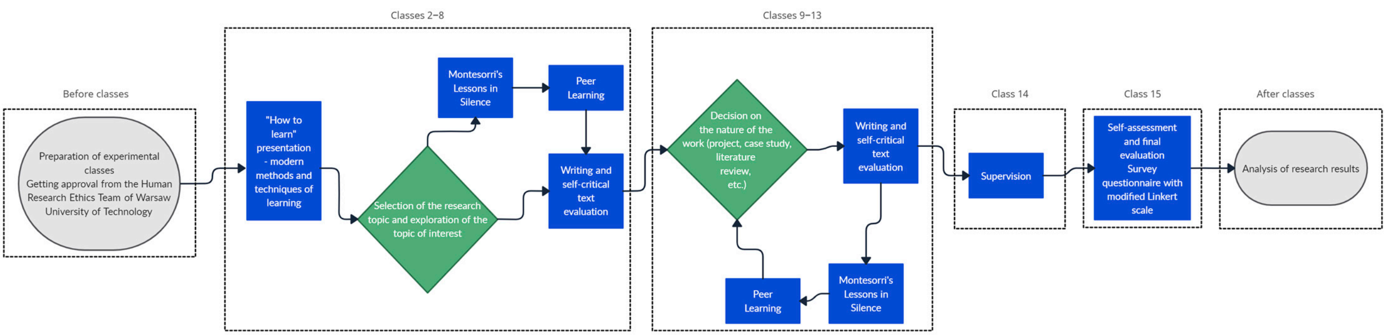

Figure 1. Flowchart of classes and research.

3. Results

The prepared research questionnaire contained 10 single-choice questions and an additional space for optional comments or feedback. Responses were prepared according to the modified (7-point) Linkert scale [35] and the instructor's experience (expert in BIM). The survey was completed by the majority of class participants (n = 27). The survey was only about the design exercises (the lecture was not the subject of the experiment and had a classic monologue form). The first question of the research survey was: "*Did the way of teaching in the so-called design exercises of the Building Information Modelling (BIM) subject differ from your previous teaching experience in other subjects at university?*" The answers clearly indicated that this was a new experience for the students and at the same time a change in favour of the previous learning experience was observed, generally from previous semesters of study (Figure 2). The experimental classes used a variety of techniques and tools with an emphasis on curiosity. This ensured that the student only explored the threads that fascinated them. A selection of them ended up with sensational, unforeseen results: the implementation of telemetry on the RFID-BIM line, the exceptionally accurate georeferencing of a BIM model in a GIS environment, or the implementation of Placemat's BIM in two large companies.

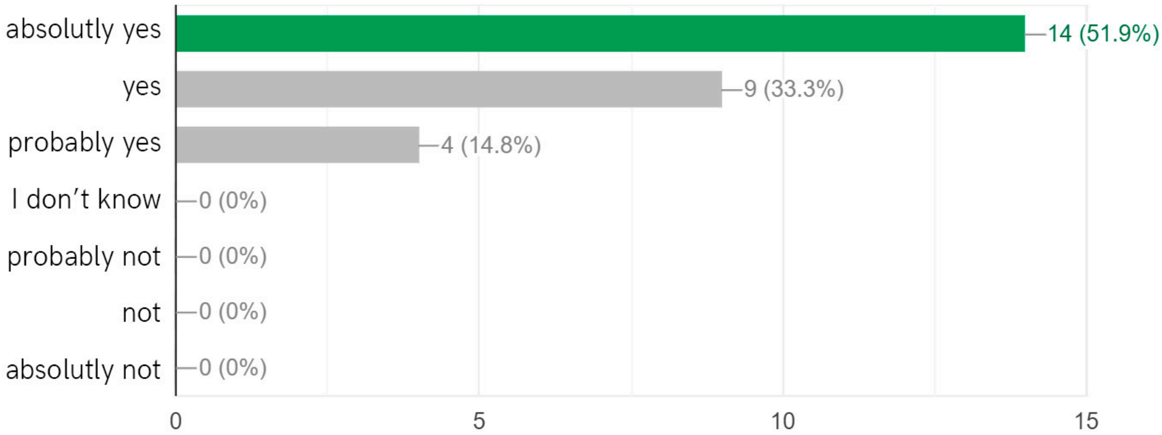

Figure 2. A clear indication of the difference between the previous classes and the experiment.

The second question was: "*Did the way the classes were conducted and the content presented in the so-called project exercises match your interests?*" Most of the answers were in the "yes" range, with a few people stating "no" or "don't know" (Figure 3). This may lead to the conclusion that the format of the class itself may have contributed to the interest and encouraged people to learn more about BIM, despite the fact that students previously had limited experience with the technology.

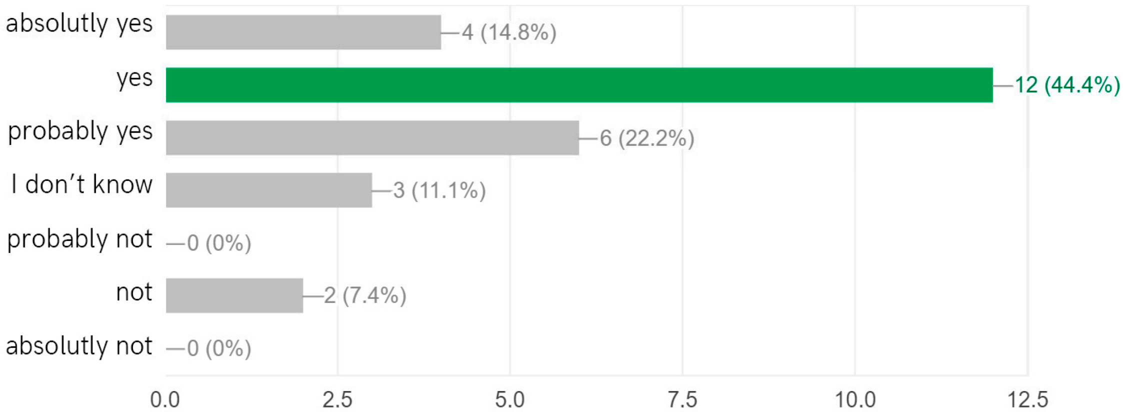

Figure 3. The format and content of the activities suited the participants in the experiment.

The third question read: "*Which of the proposed learning methods do you think is the most developmental?*" and was concerned with the different learning methods used in modern didactics. The answers varied, with challenge and project-based methods undoubtedly standing out (Figure 4). As individuals or groups of individuals chose different topics, the methods were selected according to the issues studied. However, in the peer learning process, students observed the results of other teams' research where the focus was on other methods, hence students had a broad perspective and saw the spectrum of tools that could be used.

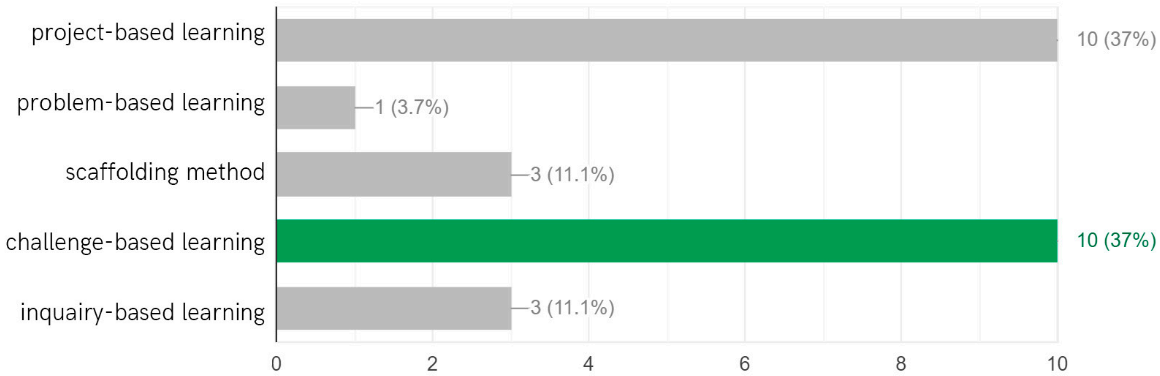

Figure 4. Selection of the most developmental teaching method according to the participants.

The fourth question was: "Do you think the proposed methods are more effective than the traditional approach (so-called 'instructionalism' and 'testomania'), where the focus is on memorising facts and reproducing procedures?". The answers here were almost unequivocal and almost all in the 'yes' range (Figure 5). Only one person answered 'don't know'. Students' experiences to date have tended to be based on learning the content, attempting to retain the content, then recalling the content and testing it [36] and, in the case of exercises and projects, reproducing procedures that often end with the same preconceived outcome. The mixed-methods approach adopted in the classroom, using a variety of learning methods, indicates greater student involvement in their learning process [37]. Also, the teacher in such a classroom format can learn from the students [38]. The two-sided model of education appears to be stronger and more beneficial than the one-sided transfer model of teaching.

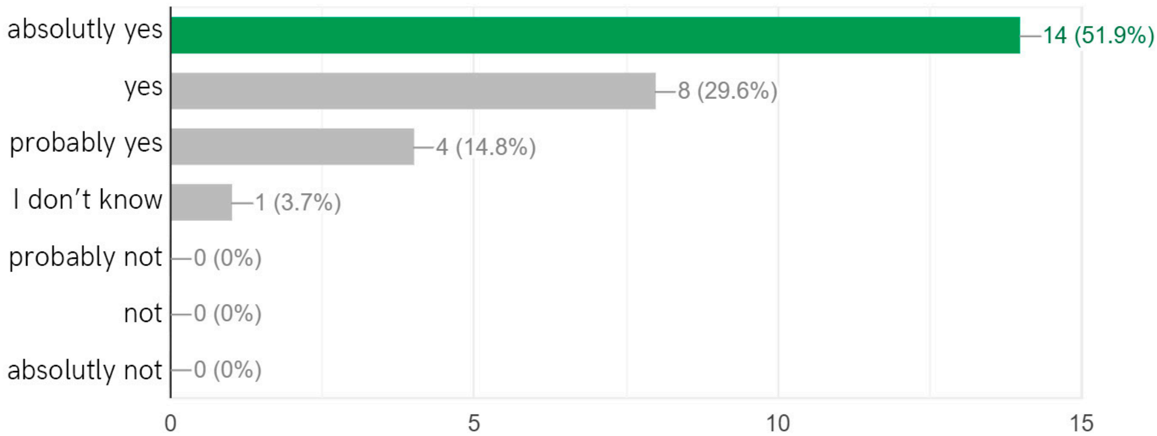

Figure 5. Strong opposition to the prevailing 'instructionalism'.

The fifth question was formulated as follows: "*Which of the potential benefits in the learning process do you consider the most valuable?*" Opinions were divided, with a large proportion of students indicating that learning new ideas and concepts in relation to prior knowledge and experience was most important. Others indicated that taking existing and new knowledge and applying it in a new context brings great value because it can fill knowledge gaps or an identified research gap (Figure 6). Filling research gaps further heightens curiosity and enhances motivation [39]. A large proportion of participants also identified the ability to recognise how patterns work and the ability to build new methodologies as key new skills.

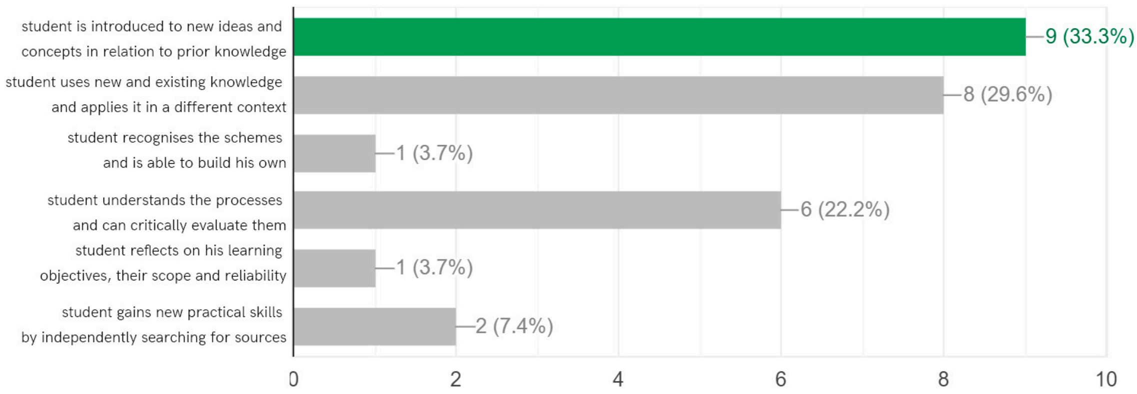

Figure 6. The most important benefits from the point of view of the student learning process.

Question six referred to the proposed process that was discussed and adopted at the outset as a classroom formula: "Do you agree with the statement: "A learning process based on presenting 'how to learn', proposing a topic, choosing a topic, orientating to the topic, conceptualising, exploring, experimenting, drawing conclusions, reflecting and describing one's own work has a number of benefits." Students were enthusiastic about this form, as evidenced by the responses, which were all in the 'yes' range (Figure 7). There was not a single response in the 'don't know' or in the 'no' ranges. This reinforces the belief that activities that are well-planned at the process level are just as important as planning at the content level [40].

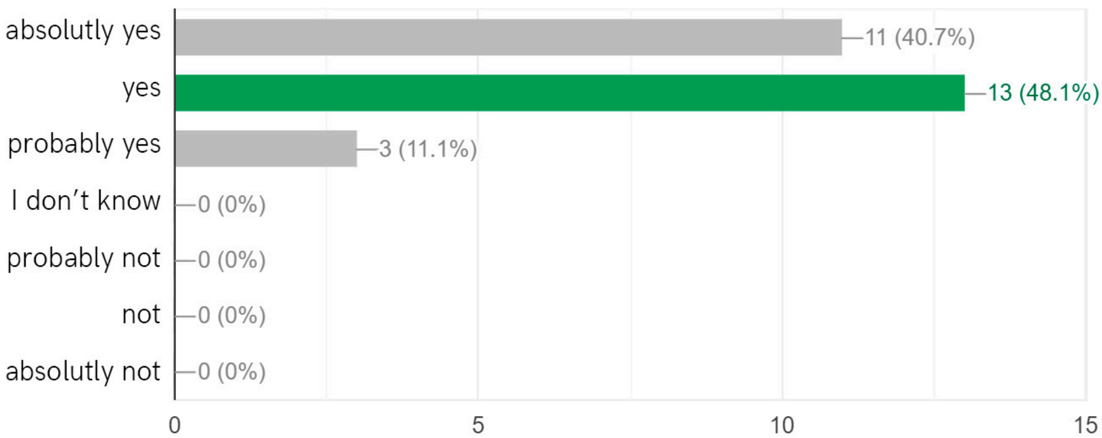

Figure 7. All felt that there were a number of benefits to the proposed class formula.

Question seven asked about the skills gained or developed during the course. Students were asked to indicate one key skill: *"Mark the skill that you think was most strongly developed during the course taught"*. There were five responses available, but students could also suggest their own (Figure 8). Depending on the topic, different skills were developed in the students. However, each group was required to write a manuscript, hence the predominance of responses included "writing and self-critical evaluation of the text" and "critical and logical thinking". Writing is one of the key skills, especially in engineering and technical sciences [41], where products, services or models must be accompanied by concise descriptions, instructions or reports. Reflecting on the results of the research conducted, on the other hand, allows participants to work at the level of metacognition or epistemic cognition, where students reflect on the purposes of science, its limits or reliability. A high response rate appeared with 'creativity'. This, in turn, confirms that curiosity triggers creativity [42], while obedience and conformity suppress it.

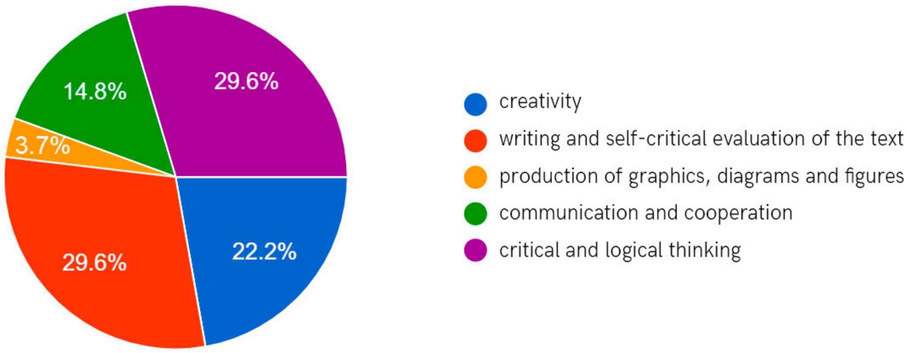

Figure 8. Creativity and writing and self-critical text evaluation are the most important skills acquired, according to students.

The eighth question in turn concerned attitudes (social competencies). Respondents were asked what they thought was the key attitude that they had developed during the course: *"Tick the attitude that you think was most strongly developed during the course"*. The responses varied, however, in favour of 'curiosity' (Figure 9). This corroborates the many academic studies that clearly indicate that companies and organisations seek graduates characterised by passion and curiosity [43] rather than intellectual conformity. Contrary to appearances, attitudes are the most difficult to develop. Knowledge and skills can be bought (e.g., a course), but their application in practice is already know-how, which may not be achievable without higher-level competencies. Competencies such as logical thinking and assertiveness, combined with simultaneous humility, are critical in work conducted at a metacognitive level and with epistemic cognition.

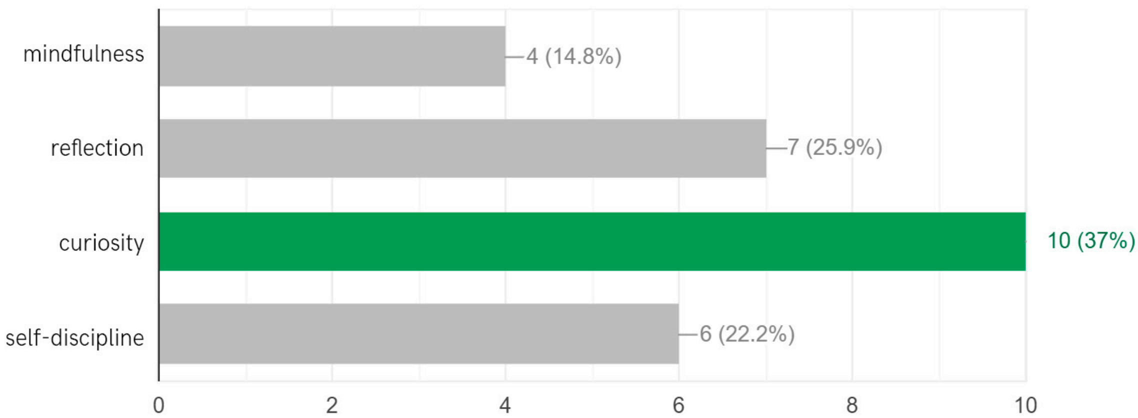

Figure 9. Attitudes that developed and strengthened in the participants of the experiment.

The ninth question asked respondents to choose between the three most popular teaching methods: authoritarian, liberal and authoritative. The question posed to the respondents was: *"Select the teaching process that best suits your personality and your needs"*. The overwhelming majority answered that the authoritative process was the most optimal (Figure 10). Thus, the students confirm recent scientific research that both authoritarian processes and overly permissive processes are not conducive to learning. The best option is an authoritative process, where the instructor is the leader (leader), provides direction, gives full feedback, and at the same time provides a friendly learning space [44].

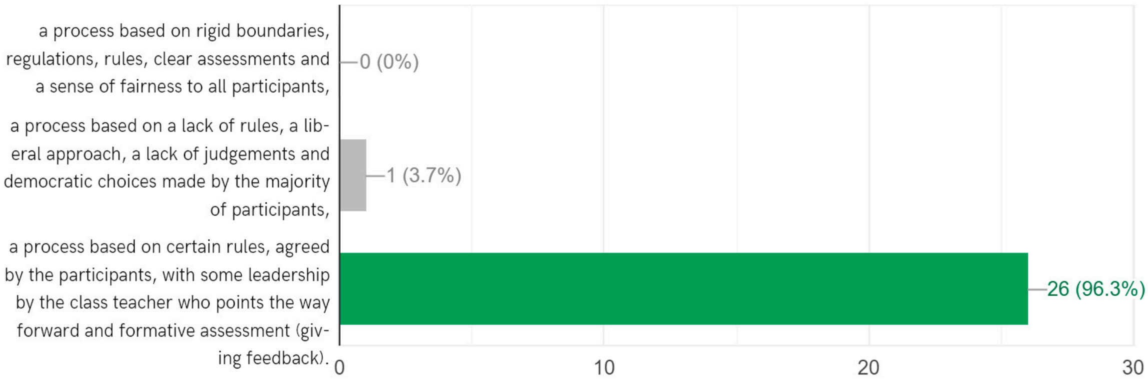

Figure 10. Most students prefer an authoritative teaching process.

The final tenth question was: "Do you agree with the statement that "peer learning (peer assessment by participants and the instructor) gives more value than presentation and digital assessment?". Here again, the majority of respondents indicated answers in the 'yes' range (Figure 11). Only two people stated "don't know". Admittedly, there is no measurable indicator to represent this value, but the subjective feelings of the students are quite clear. Some indicated in their comments that peer learning was the most developmental tool used in class.

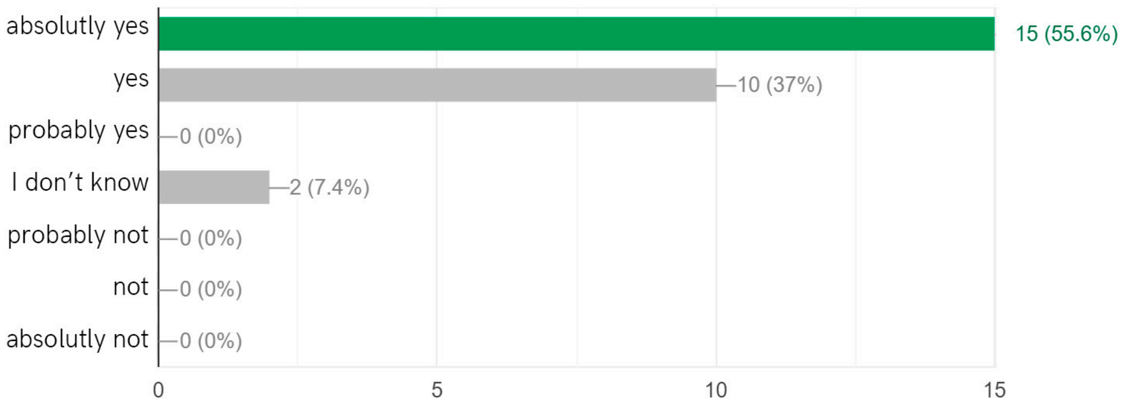

Figure 11. The majority of students see the advantages of peer learning.

At the end of the survey, the student was able to leave a comment or remark on the form of instruction. Two of these deserve mentions. The first was: "*Interesting classes: different from any that have been at the polytechnic. Although I was expecting a different convention of the class, this one also contributed a lot, especially the peer learning, which was the most interesting part of the exercises*". The student makes a strong point about the convention of the classes and peer learning, which can, in principle, be applied to any subject. The second noteworthy comment was: "*The way the class was conducted, as well as the class itself, was a very enjoyable experience. The departure from the standard way of teaching allowed me to work on a subject that actually interested me. I was able to choose what I wanted to do rather than recreating a project of the same area as the year above. It was one of the few classes that I looked forward to and came with a willingness to work. The attitude of the tutor, who tried to help and support rather than criticise, meant that the subject was not a punishment. For me personally, the result is one—I have become interested in BIM and would like to further my knowledge in this subject*". The student emphasises that the form itself results in an enhancement of curiosity and the empathy and support of the instructor are the basis for an effective learning process. It is very possible that an activated student will independently follow the path set by an informed educator.

4. Discussion

The hypothesis that project-based teaching of topics using IBL activities is much more effective than the traditional way of teaching has been proven in many studies e.g., [45]. Teachers should develop questioning skills to guide and provide timely feedback when conducting IBL [46]. In this study, IBL was reinforced with tools and techniques from other teaching methodologies. Despite the use of this approach in a research course, it seems feasible to test it in a typical engineering course [47]. The designed exercises in the proposed approach should be varied and stretched over time, thus building the strength of habit, so-called habituality [48]. Research confirms that prolonged exercises result in more lasting retention of knowledge and skills than clustered exercises, although initially, BIM content may be labile from the student's perspective due to the ongoing maturation of the technology. Planned BIM-themed classes should focus on developing competencies in information modelling, writing, verbal communication and critical thinking skills, while respecting the ethics of learning. There should be a deliberate focus on teaching the development of students' innovative thinking and problem solving [49] in the context of discipline-based curricula. This approach is often avoided by educators because of the significant amount of discipline-specific knowledge that needs to be taught and the difficulty educators have in integrating competencies with engineering.

The teacher should experiment with different forms of teaching and constantly improve his or her teaching skills. The IBL method is one of many possible methods that a didactician can test. When dealing with technical subjects, it is worth ensuring that the challenges posed are tailored to the current state of knowledge and technology and use modern technologies. The pragmatism and utilitarianism of problems will drive student motivation. However, it seems that every teacher, regardless of the discipline, should have a basic knowledge of neuroscience, cognitive psychology and pedagogy. At this point, it should be emphasised that didactic competence is the sum of technical competence with relational competence [50]. Thus, the teacher should be aware of all forms of expression of students' mental states—surprise, boredom, fluency, emergence of new ideas, feigned attention and so on. He or she should respond to them maturely and with respect for the student. In the presence of a sensitive and empathetic teacher, students take responsibility for their own performance, charting an individual path of development. In this way, the most effective learning will be learning that flows from their own desire to learn [51]. The environment created and provided by the teacher will have a positive impact on the student, who, becoming self-taught, will continue their education throughout their lives. Thus, perhaps he will fall into the so-called learning spiral, and the more he knows, the more he will want to learn [52].

How can a professor apply IBL to his teaching? Assuming he has very broad domain knowledge and excellent technical skills, he should focus on testing and experimenting with IBL techniques or other approaches. It is impossible to become a great teacher by observing or reading. One must try to apply the techniques mentioned in educational practice. It is worth starting with an overview of the wide range of techniques mentioned in this article: peer learning, flipped lesson, Montessori's silent lesson, self-assessment, supervision, conscious training, real conversation, facilitation and activity marking. At the first opportunity, it is good to explain to students why the instructor has chosen such forms of teaching and how they will affect their learning process. At the very least, the teacher should introduce students to the basics of the phenomenon of neurogenesis, discuss how the declarative versus procedural system works and explain the importance of knowledge consolidation and retention. If students are aware of these mechanisms, they will more easily agree to such a formula for classes.

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 routines and formulas. Spontaneous neoteny was rarely allowed, yet it is the propensity to play with the topic of interest that leads to development. Hence, this approach decided to move away from traditional methods and try a hybrid approach. In contrast to 'instructionalism' and 'testomania', the proposed blended approach allows students to develop higher-order thinking through real-world problem solving or gamification, rather than assimilating facts and reproducing instructions. The ubiquitous concept of grading students and dividing them into winners and losers should give way to the empathetic, respectful and supportive idea of teacher–student collaboration. Digital assessment only theoretically indicates to society the value in terms of knowledge or skills. However, research clearly indicates that digital assessments can be counter-productive and detrimental to learning. Hence, activity-marking and formative assessments are a better solution, as long as the instructor controls the students' learning process at all times. The results of such cooperation are not required to be measurable at all; what is more important is the satisfaction, joy and value it brings. Through a friendly learning space, both teachers and students learn, climbing to higher and higher levels of proficiency. Applying the approach presented is not easy, but it can give much satisfaction to both parties if they recognise that the synergy of their joint efforts can lead to discovery and creation. The latest reports from neuroscience, cognitive psychology or pedagogy should encourage teachers to continuously improve their teaching skills.

Planning, monitoring and reflecting are significant in effective student learning and play a key role not only in inquiry-based learning. They can also help to structure the content of the curriculum across subjects. A focus on inquiry-based learning often exceeds general curriculum expectations. Instead, it supports integrative and creative thinking about the curriculum and students' independent learning. By implementing inquiry-based learning, students benefit by seeing a multiplicity of possible perspectives on a particular problem. Students learn largely through collaboration and focus on correcting their own mistakes. A culture of learning from mistakes should replace the previous culture of obedience and pervasive rigid frameworks.

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Institutional Review Board Statement: This study was conducted in accordance with ethical guidelines and approved by the Ethics Team for Scientific Research with Human Participation of Warsaw University of Technology (protocol number 05/2024 and date of approval 6 March 2024).

Informed Consent Statement: During the experiment, all participants were informed of background information about the study, and we obtained written, explicit consent from both subjects. To ensure confidentiality, all students' personal identifiers were removed prior to data processing. Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to specific data acquisition tools.

Conflicts of Interest: The author declares no conflict of interest.

References

1. De Jong, T. Technological advances in inquiry learning. *Science* **2006**, *312*, 532–533. [CrossRef]
2. Summerlee, A.J. Inquiry-based learning: A socially just approach to higher education. *J. Hum. Behav. Soc. Environ.* **2018**, *28*, 406–418. [CrossRef]
3. Spronken-Smith, R. Experiencing the process of knowledge creation: The nature and use of inquiry-based learning in higher education. In *International Colloquium on Practices for Academic Inquiry*; University of Otago: Dunedin, New Zealand, 2012; pp. 1–17.
4. Hasan, R.; Lukitasari, M.; Utami, S.; Anizar, A. The activeness, critical, and creative thinking skills of students in the Lesson Study-based inquiry and cooperative learning. *JPBI (J. Pendidik. Biol. Indones.)* **2019**, *5*, 77I 84. [CrossRef]
5. Chan, Y.F.; Sidhu, G.K.; Suthagar, N.; Lee, L.F.; Yap, B.W. Relationship of inquiry-based instruction on active learning in higher education. *Pertanika J. Soc. Sci. Humanit.* **2016**, *24*, 55–72.
6. Dickson, C.A.W. Evaluating the student experience of inquiry-based learning: An educational initiative. *Pract. Evid. Scholarsh. Teach. Learn. High. Educ.* **2010**, *5*, 33–45.

7. Nguyen, H.B.N.; Chen, M.L.; Hong, J.C.; Lee, Y.F. Developing an educational policy acceptance model to explore the implementation of Vietnamese teachers' inquiry-based teaching. *Asia Pac. J. Educ.* **2023**, 1–17. [CrossRef]
8. Avsec, S.; Kocijancic, S. Effectiveness of inquiry-based learning: How do middle school students learn to maximise the efficacy of a water turbine. *Int. J. Eng. Educ.* **2014**, *30*, 1436–1449.
9. Erlina, N.; Susantini, E.; Wicaksono, I.; Pandiangan, P. The Effectiveness of Evidence-Based Reasoning in Inquiry-Based Physics Teaching to Increase Students' Scientific Reasoning. *J. Balt. Sci. Educ.* **2018**, *17*, 972–985. [CrossRef]
10. Handayani, A.D.; Herman, T.; Fatimah, S.; Setyowidodo, I.; Katminingsih, Y. Inquiry-based learning: A student centered learning to develop mathematical habits of mind. *J. Phys. Conf. Ser.* **2018**, *1013*, 012115. [CrossRef]
11. Olitsky, S. Crossing the boundaries: Solidarity, identity, and mutual learning in a K-20 partnership. *Sci. Educ.* **2017**, *101*, 399–425. [CrossRef]
12. Tal, T.; Levin-Peled, R.; Levy, K.S. Teacher views on inquiry-based learning: The contribution of diverse experiences in the outdoor environment. *Innov. Educ.* **2019**, *1*, 1–17. [CrossRef]
13. Levy, P.; Petrulis, R. How do first-year university students experience inquiry and research, and what are the implications for the practice of inquiry-based learning? *Stud. High. Educ.* **2012**, *37*, 85–101. [CrossRef]
14. Randall, D.A.C.; Moore, C.; Carvalho, I.S. An international collaboration to promote inquiry-based learning in undergraduate engineering classrooms. *Campus-Wide Inf. Syst.* **2012**, *29*, 259–271. [CrossRef]
15. Pedaste, M.; Mäeots, M.; Siiman, L.A.; De Jong, T.; Van Riesen, S.A.; Kamp, E.T.; Manoli, C.C.; Zacharia, Z.C.; Tsourlidaki, E. Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educ. Res. Rev.* **2015**, *14*, 47–61. [CrossRef]
16. Barron, B.; Darling-Hammond, L. Prospects and challenges for inquiry-based approaches to learning. In *The Nature of Learning: Using Research to Inspire Practice*; Organisation for Economic Cooperation and Development (OECD): Paris, France, 2010; pp. 199–225.
17. Chung, H.M.; Behan, K.J. Peer sharing facilitates the effect of inquiry-based projects on science learning. *Am. Biol. Teach.* **2010**, *72*, 24–29. [CrossRef]
18. Jones, G.J. An inquiry-based learning approach to teaching information retrieval. *Inf. Retr.* **2009**, *12*, 148–161. [CrossRef]
19. Duran, M.; Dökme, I. The effect of the inquiry-based learning approach on student's critical-thinking skills. *Eurasia J. Math. Sci. Technol. Educ.* **2016**, *12*, 2887–2908. [CrossRef]
20. Zubaidah, S.; Fuad, N.M.; Mahanal, S.; Suarsini, E. Improving creative thinking skills of students through differentiated science inquiry integrated with mind map. *J. Turk. Sci. Educ.* **2017**, *14*, 77–91.
21. Panasan, M.; Nuangchalerm, P. Learning outcomes of project-based and inquiry-based learning activities. *Online Submiss.* **2010**, *6*, 252–255. [CrossRef]
22. Casey, L. Questions, curiosity and the inquiry cycle. *E-Learn. Digit. Media* **2014**, *11*, 510–517. [CrossRef]
23. Tadjer, H.; Lafifi, Y.; Seridi-Bouchelaghem, H.; Gülseçen, S. Improving soft skills based on students' traces in problem-based learning environments. *Interact. Learn. Environ.* **2022**, *30*, 1879–1896. [CrossRef]
24. Papasarantou, C.; Alimisi, R.; Alimisis, D. Virtual Galleries as Learning Scaffolds for Promoting Problem-Based Learning. *Educ. Sci.* **2023**, *13*, 1168. [CrossRef]
25. Mika, M.; Leń, P.; Oleniacz, G.; Kurowska, K. Study of the effects of applying a new algorithm for the comprehensive programming of the hierarchization of land consolidation and exchange works in Poland. *Land Use Policy* **2019**, *88*, 104182. [CrossRef]
26. Zima, K.; Ciepłucha, W. Efficiency Analysis of Roadway Lighting Replacement in a Selected Polish Municipality. *Appl. Sci.* **2023**, *13*, 3257. [CrossRef]
27. Maciąg, K.; Leń, P. Assessment of 3D Geoportals of Cities According to CityGML Standard Guidelines. *Sustainability* **2022**, *14*, 15578. [CrossRef]
28. Plebankiewicz, E.; Meszek, W.; Zima, K.; Wieczorek, D. Probabilistic and fuzzy approaches for estimating the life cycle costs of buildings under conditions of exposure to risk. *Sustainability* **2019**, *12*, 226. [CrossRef]
29. Szóstak, M. Best Fit of Cumulative Cost Curves at the Planning and Performed Stages of Construction Projects. *Buildings* **2022**, *13*, 13. [CrossRef]
30. Borkowski, A.S. Evolution of BIM: Epistemology, genesis and division into periods. *J. Inf. Technol. Constr.* **2023**, *28*, 646–661. [CrossRef]
31. Sollaci, L.B.; Pereira, M.G. The introduction, methods, results, and discussion (IMRAD) structure: A fifty-year survey. *J. Med. Libr. Assoc.* **2004**, *92*, 364.
32. Lillard, A.S. Mindfulness practices in education: Montessori's approach. *Mindfulness* **2011**, *2*, 78–85. [CrossRef]
33. Boud, D.; Cohen, R. *Peer Learning in Higher Education: Learning from and with Each Other*; Routledge: London, UK, 2014.
34. van Rensburg, G.H.; Mayers, P.; Roets, L. Supervision of post-graduate students in higher education. *Trends Nurs.* **2016**, *3*. [CrossRef]
35. Croasmun, J.T.; Ostrom, L. Using likert-type scales in the social sciences. *J. Adult Educ.* **2011**, *40*, 19–22.
36. McDaniel, M.A.; Bugg, J.M.; Liu, Y.; Brick, J. When does the test-study-test sequence optimize learning and retention? *J. Exp. Psychol. Appl.* **2015**, *21*, 370. [CrossRef] [PubMed]
37. Ayllón, S.; Alsina, Á.; Colomer, J. Teachers' involvement and students' self-efficacy: Keys to achievement in higher education. *PLoS ONE* **2019**, *14*, e0216865. [CrossRef] [PubMed]

38. Wallace, J.; Loughran, J. Science teacher learning. In *Second International Handbook of Science Education*; Springer: Dordrecht, The Netherlands, 2012; pp. 295–306.
39. McIntyre, D. Bridging the gap between research and practice. *Camb. J. Educ.* **2005**, *35*, 357–382. [CrossRef]
40. McIlrath, D.; Huitt, W. The teaching-learning process: A discussion of models. *Educ. Psychol. Interact.* **1995**, *4*, 45–49.
41. Selwyn, R.; Renaud-Assemat, I. Developing technical report writing skills in first and second year engineering students: A case study using self-reflection. *High. Educ. Pedagog.* **2020**, *5*, 19–29. [CrossRef]
42. Daher, W.; Gierdien, F.; Anabousy, A. Self-efficacy in creativity and curiosity as predicting creative emotions. *JRAMathEdu (J. Res. Adv. Math. Educ.)* **2021**, *6*, 86–99. [CrossRef]
43. Chang, Y.Y.; Shih, H.Y. Work curiosity: A new lens for understanding employee creativity. *Hum. Resour. Manag. Rev.* **2019**, *29*, 100672. [CrossRef]
44. Kolb, A.; Kolb, D. Eight important things to know about the experiential learning cycle. *Aust. Educ. Lead.* **2018**, *40*, 8–14.
45. Gerhátová, Ž.; Perichta, P.; Drienovský, M.; Palcut, M. Temperature measurement-Inquiry-Based learning activities for third graders. *Educ. Sci.* **2021**, *11*, 506. [CrossRef]
46. Cai, S.; Niu, X.; Wen, Y.; Li, J. Interaction analysis of teachers and students in inquiry class learning based on augmented reality by iFIAS and LSA. *Interact. Learn. Environ.* **2023**, *31*, 5551–5567. [CrossRef]
47. Yadav, R.; Tiruwa, A.; Suri, P.K. Internet based learning (IBL) in higher education: A literature review. *J. Int. Educ. Bus.* **2017**, *10*, 102–129. [CrossRef]
48. Gillan, C.M.; Robbins, T.W.; Sahakian, B.J.; van den Heuvel, O.A.; van Wingen, G. The role of habit in compulsivity. *Eur. Neuropsychopharmacol.* **2016**, *26*, 828–840. [CrossRef] [PubMed]
49. Griffin, A.S.; Guez, D. Innovation and problem solving: A review of common mechanisms. *Behav. Process.* **2014**, *109*, 121–134. [CrossRef] [PubMed]
50. Juul, J.; Jensen, H. *Relational Competence: Towards a New Culture of Education*; Mathias Voelchert GmbH Verlag: Windberg, Germany, 2017.
51. Borkowski, A.S. Experiential learning in the context of BIM. *STEM Educ.* **2023**, *3*, 190–204. [CrossRef]
52. Raisch, S.; Hargrave, T.J.; Van De Ven, A.H. The learning spiral: A process perspective on paradox. *J. Manag. Stud.* **2018**, *55*, 1507–1526. [CrossRef]