Journal of Engineering Education Transformations ,
Volume 39, No. 1 , July 2025 , ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2025/v39i1/25118

Flexible Education - A Paradigm Shift in Engineering Pedagogy

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Abstract—This research presents a novel pedagogical model termed "Flexible Education", designed to tailor learning experiences to the unique needs of each student and align educational content with the dynamic job market. Unlike traditional methods, "Flexible Education" fosters an inclusive learning environment through e-learning, ongoing assessment, and active student participation. At the heart of our methodology are several fundamental principles: flexible teaching strategies, real-time e-learning resources, problem-based learning, active learning techniques, and feedback mechanisms. We employ assessment methods such as student-led presentations and group activities to stimulate critical thinking and digital literacy. Workshops and collaborative sessions are integral to our model, aiming to equip students with essential skills for their future professions. Our empirical analysis, based on student performance indicators, demonstrates significant improvements in critical thinking, engagement, technological proficiency, teamwork, and problem-solving abilities. This underscores the effectiveness of the "Flexible Education" model in enhancing various aspects of student learning.

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Keywords— Adaptive curriculum; Collaborative learning; Engineering education; Student-led teaching.

1. Introduction

In the span of thirty years teaching engineering courses at the graduate level, the authors have realized that a professor's knowledge is not the only factor that influences student learning and motivation. Despite a professor's dedication to teaching, students must also be open to learning in order to fully grasp and excel in the subject matter. However, it is the professor's duty to guide all students and assist them in developing their skills and expertise, enabling them to become competent professionals capable of solving a range of engineering problems.

Conventional educational approaches often revolve around students completing quizzes and exercises designed to facilitate learning. However, if students fail to achieve satisfactory results, they may be required to retake the course, potentially impacting their motivation and self-confidence. This could lead them to believe that they are ill-suited for the subject or incapable of effective learning. It is crucial to acknowledge that students possess diverse talents and learning styles, and their academic performance should not be evaluated against a single standard. The crux of the matter lies in the fact that students are not inherently unable to learn, but rather that teaching methods and materials are frequently not tailored to their individual needs and abilities. Just as each person has a unique fingerprint, every individual possesses a unique talent that is crucial to their chosen field of study. Professors must identify and nurture these talents and abilities. To achieve this, a teaching plan must be developed that can identify students' strengths and interests and align them with suitable topics.

This study introduces a comprehensive teaching strategy termed “flexible education”, which emphasizes flexibility in both the mode of participation—whether in person, online, or offline—and in choosing topics of interest from the course's table of contents. This approach is a step towards discovering students' inherent talents. By allowing students to learn independently about their chosen topics and present their findings to the class, they are encouraged to engage deeply with the material. Feedback from peers and professors helps them identify areas for improvement and guides further study. Peer teaching fosters a deeper understanding, as students must master the material well enough to teach it. Ultimately, this method aims to develop students' expertise in specific fields, enabling them to build their future careers based on their strengths and collaborate effectively with classmates who excel in other areas.

Recent studies have emphasized the necessity of adapting engineering education methodologies to better align with modern pedagogical principles and industry expectations. Irfan, Rajamallaiah, and Ahmad (2018) advocate for the integration of design thinking into engineering curricula, highlighting its role in fostering creativity, adaptability, and problem-solving skills. This shift complements the flexible education model, where students take an active role in exploring topics that resonate with their strengths and career ambitions.

Moreover, Shekhawat, Husain, and Patil (2019) stress the importance of reforming engineering education systems, particularly in addressing employability challenges. Their insights reinforce the need for student-centered learning frameworks, ensuring students gain practical competencies alongside theoretical knowledge. This aligns well with the principles of personalized learning, allowing students to shape their educational journeys in ways that maximize their skill development.

Peer-driven learning has also emerged as a powerful mechanism for enhancing student engagement. Shete et al. (2021) examine the impact of technical student clubs in cultivating self-directed learning and peer collaboration, providing students with hands-on experiences that refine their technical expertise. Such initiatives resonate strongly with the peer teaching approach embedded in flexible education, enabling students to deepen their understanding through mentorship and shared learning experiences.

Additionally, bridging the gap between theoretical knowledge and experiential learning remains an essential objective in modern engineering education. Godihal (2024) underscores the significance of onsite immersions, where students engage in practical applications of engineering principles. This fusion of theory and practice aligns with flexible education, reinforcing the necessity of dynamic and adaptable learning environments that cater to diverse student needs.

The evolving landscape of engineering education has seen a significant trend towards the adoption of various innovative teaching methodologies and strategies. This includes the emphasis on project-based learning (PBL), outcome-based education (OBE), active learning techniques (ALT), and experiential learning courses (ELC). A number of academic studies have highlighted the effectiveness of these approaches in enhancing student knowledge, skills, and employability within the field of engineering. For instance, Munje (2022) has discussed the positive impact of PBL in improving student knowledge and skills in Electrical Engineering, while Adamuthe and Patil (2020) have proposed a roadmap to enhance problem-solving skills in computer science and information technology students. Prasad and Reddy (2015) have presented a project-based and active learning teaching methodology for embedded system engineering education, and Brailas et al. (2017) have highlighted the effectiveness of an experiential learning course on research methodology.

Further research has explored specialized pedagogical approaches that enhance subject-specific expertise and employability outcomes. Nethravathi and Geetha (2015) described a teaching methodology tailored for power system analysis, while Raju and Kumar (2021) analyzed the challenges and benefits of teaching entrepreneurship to engineering graduates. Similarly, Ghaemi and Yadav (2019) demonstrated the enhancement of student retention and satisfaction in cellular physiology and biophysics through problem-based learning (PBL), and Anderson and Plumb (2018) highlighted the integration of sustainability topics into a core chemical engineering fluid dynamics course.

In addition, there is a growing emphasis on enhancing the employability skills of engineering students. For example, Ali and Harris (2021) examined the transformation of employability skills through cooperative programs, while Balasubramani (2015) emphasized the importance of soft and technical skills training in preparing students for professional success. Research by Izam and Hasan (2022) addressed unemployment issues among Vocational Stream Students with Learning Disabilities (VSSwLD) in Malaysia, and Bhatti et al. (2022) explored the cultural influences on employability skills in different regions.

Several scholars have further expanded the discourse on engineering education innovations. Barak, Ginzburg, and Erduran (2024) advocate for the integration of engineering principles into school curricula, improving engineering literacy at an early stage. Winkens, Lemke, and Leicht-Scholten (2024) underline the importance of resilience thinking, essential for preparing students to address complex, real-world engineering challenges. Hindhede and Højbjerg (2022) delve into marine engineering education, while Mohammadi, Khodaie, and Eshaghi (2024) examine the alignment between Iran's engineering education and labor market demands. Additionally, Beigpourian and Ohland (2024) assess psychological safety in team-based learning, Van Grunsven, Stone, and Marin (2023) stress the importance of socio-ethical considerations in emerging technologies, and Doulougeri et al. (2024) provide a comprehensive review of Challenge-Based Learning (CBL).

Together, these studies underscore the value of flexible, personalized, and collaborative approaches to learning. In response to these insights, our research introduces the flexible education approach, which combines a dynamic curriculum with peer teaching and collaborative learning. This innovative strategy aims to enhance educational outcomes, strengthen individual strengths, and improve employability skills.

Following this introduction, Section 2 describes the methodology. Section 3 presents a case study, Section 4 evaluates the proposed method, Section 5 discusses conclusions and implications, and Section 6 suggests future research directions.

2. Methodology

The teaching methodology that we introduce in this section places a strong emphasis on tailoring learning experiences to individual needs and fostering skill development, thereby empowering students to excel in their areas of strength. We have coined our approach “flexible education” to encapsulate the essence of our educational philosophy. To provide a clearer understanding of our approach, we have conducted a comparative review between our method and traditional education, which is summarized in Table 1. The comparison reveals that traditional education and “flexible education” represent distinct learning approaches, each with its own set of advantages and drawbacks. In traditional education, students often rely on specific sources such as textbooks and lectures from professors for learning materials, potentially limiting the diversity and dynamism of the learning experience. On the other hand, “flexible education” allows students to access a wide range of free resources on the Internet, resulting in a more diverse and dynamic learning experience. Furthermore, in a traditional education setting, the professor typically assumes the role of the primary speaker and leader of the class, potentially leading to a more passive learning environment for students. In contrast, “flexible education” provides opportunities for students to give talks and contribute to the learning process, fostering public speaking skills and creating a more interactive and engaging learning environment. Another notable distinction lies in the alignment of the curriculum with labor market requirements. Traditional education may not always closely align with the demands of the labor market, whereas “flexible education” ensures that the curriculum is designed to equip students with the skills and knowledge needed for their future careers. Assessment methods also differ between the two approaches. Traditional education often relies solely on written and oral in-person exams during the midterm and final semester, whereas “flexible education” involves students challenging each other in each session, with the learning process being continuously monitored. This allows for a more comprehensive and ongoing evaluation of students' progress. Moreover, while classroom management is solely the responsibility of the professor in traditional education, “flexible education” involves students in

Table I :
A Brief Comparison of the Main Features of Traditional Education and Our Proposed "Flexible Education".

Traditional Education	Flexible Education
Students typically rely on one specific source for their learning materials, such as textbooks and lectures from the professor.	Students have access to a wide range of free resources through the Internet, allowing for a more diverse and dynamic learning experience.
The teacher is the sole person speaking and leading the class.	Students also have the opportunity to give talks and contribute to the learning process. This not only gives students a chance to develop their public speaking skills but also fosters a more interactive and engaging learning environment.
The curriculum may not always be as closely aligned with the labor market requirements.	The curriculum is designed to align with the demands of the labor market, ensuring that students are equipped with the skills and knowledge needed for their future careers.
Students are typically graded solely based on written and oral in-person exams during the midterm and final semester.	Students challenging each other in each session and the learning process being monitored continuously. This allows for a more comprehensive and ongoing evaluation of students' progress.
Classroom management is solely the responsibility of the professor.	Students are also involved in the management process under the supervision of the professor.
Learning is often limited to a select group of students.	Most students have the chance to learn and contribute to the learning process.
Students typically rely on one specific source for their learning materials, such as textbooks and lectures from the professor.	Students have access to a wide range of free resources through the Internet, allowing for a more diverse and dynamic learning experience.

the management process under the supervision of the professor, imparting a sense of ownership and responsibility for their learning environment. Finally, in traditional education, learning is often confined to a select group of students, whereas "flexible education" offers the chance for most students to learn and contribute to the learning process. In conclusion, both traditional education and "flexible education" possess their own strengths and weaknesses. While traditional education may provide a more structured and familiar learning environment, "flexible education" offers a more diverse, dynamic, and interactive approach to learning.

A. Needed preparations and general aspects of the methodology

One of the fundamental pillars of our approach centers on the proactive preparation of professors for problem-based education ahead of each academic semester. This preparation process involves an iterative approach, drawing insights from current educational trends and leveraging resources from previous years. The updating process is rooted in a thorough curriculum review method, which takes into consideration the present needs, expectations, and standards of students, society, and the profession. This method ensures that the curriculum remains pertinent and effective in addressing contemporary challenges. In addition to the curriculum review, our methodology places significant emphasis on the integration of e-learning, as highlighted by Retscher et al. (2022). E-learning is deemed a critical component of our approach, providing students with the flexibility to engage in real-time class activities using the available e-learning infrastructure of universities. Additionally, students have the option to access recorded class materials in cases where they are unable to attend in-person or online. It is important to note that students attending in-person are required to bring their laptops to access the virtual class through the e-learning platform, enabling them to utilize the full suite of tools available within the e-learning system, access the Internet, and leverage online resources and artificial intelligence (AI) to enhance their learning experience. Furthermore, the integration of in-person and e-learning facilitates seamless interaction between students attending in-person and those participating online, fostering an inclusive and collaborative learning environment. This approach aligns with Gold's problem-based teaching method, which underscores the effectiveness of applying technology to improve the outcomes of hydrography engineering students (MyPBLWorks, 2023). In evaluating learning outcomes, the authors utilized all six steps of Bloom's updated classification, as outlined by Anderson et al. (2001). By incorporating these elements into the methodology, we aim to create an educational environment that is responsive to the evolving needs of students and the demands of the professional landscape. This proactive and comprehensive approach ensures that the curriculum remains dynamic and adaptable, while also fostering a learning environment that leverages the benefits of both in-person and e-learning modalities.

B. Methodology design

Our methodology is designed to provide students with a comprehensive understanding of the subject matter and equip them with the necessary skills and knowledge. During the first week of the course, the focus is on the course's objectives, which include teaching students how to present material effectively and accurately express problems, as well as the desired learning outcomes, such as deep learning and collaboration among students. The professor provides an overview of the curriculum structure, which is designed to equip students with the necessary skills and knowledge for the subject. Real-life examples are used to demonstrate the relevance of the course content and its potential applications in various job settings. The primary aim of the first week is to inspire students, cultivate their interest in the discipline, and prepare them for the upcoming weeks. The course materials, including a list of contents and current references, are distributed to students. The teaching assistant also introduces students to basic research methodology, focusing on Internet search techniques and effective use of artificial intelligence (AI). Students are then required to select topics for their seminar and problem, conduct independent research using the provided materials, and present their findings in subsequent sessions.

In the following week, students review their chosen subjects and deliver concise presentations, receiving feedback from the professor on both the scientific aspect and the quality of their research. Students are encouraged to refine their presentations and adhere to reporting standards. Collaboration among students is also encouraged, and students may work together as a team to divide the workload for more comprehensive presentations. Additionally, starting from the second week, students are encouraged to ask questions in the classroom to deepen their understanding of the topics presented.

The process of identifying strengths and encouraging further development continues until the professor is able to help students deepen their knowledge in their areas of interest and talent. Instead of forcing students to cover all subjects, the professor assists them in focusing on their strengths. In addition, students are given the opportunity to give lectures to the class, with each session tailored to the needs of students in their field of study, by the teaching assistant. This includes monitoring the progress or regression of students' critical thinking, interest in learning, proper use of technology and software, and collaboration with other students. This method is based on the educational principle that active reading is more effective than passive listening, and that teaching others can help identify and resolve gaps in knowledge (Chang & Milt 2019).

It is noteworthy that the professor and teaching assistant play crucial roles in facilitating this approach, with a strong emphasis on feedback and student engagement. The feedback loop between the teaching assistant, students, and professor is a key component of this approach. By providing feedback to the professor before each class, the teaching assistant ensures that the professor can tailor the course content to address any misconceptions or areas that require further study. In turn, the professor provides feedback to the students, offering insights into their understanding of the material and guiding them on areas that need improvement. This reciprocal exchange of feedback creates a dynamic learning environment where both students and the professor are actively involved in the learning process.

Additionally, the approach emphasizes student responsibility and active participation. Students who take on the role of speaker are not only responsible for their own learning but also contribute to the learning of their peers. This encourages a collaborative learning environment where students are actively engaged in sharing knowledge and supporting each other's learning. The professor's role in delivering clear and engaging lectures, while also encouraging student evaluation and engagement, is crucial in this approach. By encouraging students to evaluate the effectiveness of lectures and engaging them with questions, the professor promotes critical thinking and active participation in the classroom. The additional support provided by the professor to reinforce learning further enhances the learning experience for students.

The teaching assistant's use of an improvement checklist in each session to monitor student progress in various aspects is commendable. This checklist helps assess the effectiveness of the educational approach and its impact on critical thinking, collaboration, technology use, and a passion for learning. By continuously measuring student progress, the teaching assistant can provide valuable feedback to the professor. This feedback allows for adjustments to the teaching methods based on the students' abilities and readiness, ensuring an enhanced learning experience and the promotion of essential skills beyond the traditional classroom setting. Additionally, categorizing students according to Bloom's taxonomy and closely monitoring their progress in key skills highlights the focus on individual student growth and development, ensuring that each student's learning needs are effectively addressed.

In addition to the previously mentioned approach for assessing students' progress, we have found another method to be successful in both assessment and further fostering their problem-based learning ability. This method involves introducing new challenges around the 12th week of the semester, which can be tailored to require students to work in pairs and focus on topics that are relevant to the needs of the country. It is recommended that these tasks be completed within a single lecture hour, and students should be encouraged to utilize artificial intelligence (AI) as a tool to solve the challenges. For example, in our case study, the topic “improving hydrographic techniques using new technologies” was adopted, which was proposed by the National Geographical Organization during the yearly national fair of geomatic developments called IranGeo. The results of this assessment were found to be insightful and interesting, indicating the positive impact of the sessions on the students' abilities. This approach not only allows students to apply their knowledge in a practical setting but also encourages them to think critically and creatively. By incorporating real-world challenges into the curriculum, professors can effectively gauge the progress and capabilities of their students.

In the final weeks of the semester, it is important to shift our educational focus towards practical application of the capabilities and talents that students have demonstrated throughout the course. By conducting workshops aimed at harnessing these skills, we can provide students with valuable opportunities to actively engage in roles that align with their strengths. During these workshops, it is crucial to use the information gathered throughout the semester to inform students of their observed talents and to allocate them to workshops where they can thrive. For example, we can inform student 1 of their exceptional ability to generate innovative problem-solving ideas, student 2 for their strong research skills, student 3 for their effective facilitation of brainstorming due to their background in an executive role, student 4 for their consistent ability to challenge peers and seek explanations, student 5 for fostering a highly collaborative spirit, and student 6 for their fluency in speaking and delivering compelling presentations. By assigning tasks to one another in the workshop based on their talents, we can create an environment where each student can contribute meaningfully.

To complement the course, it is recommended that the last few sessions be conducted in a workshop format. During these workshops, students can be tasked with presenting their understanding of syllabus topics that were not covered in class. This approach aligns with our methodology, which does not require covering the entire syllabus during regular sessions, making it a valuable addition. It also serves as a collaborative exercise that emphasizes the importance of teamwork and individual empowerment.

The professor can ask students to form groups of four, with each group selecting a topic not previously covered. Each group then designates a speaker to present their findings. Our practical experience has shown that this method improves students' ability to articulate and convey information, indicating an enhancement in their emotional intelligence. This approach not only reinforces the course material but also fosters essential skills in communication and collaboration.

In summary, our experience with this teaching methodology across various courses and semesters has demonstrated significant benefits. As we approach the final week of the semester, we observe a notable evolution in student engagement. Students begin to actively participate in discussions, showcasing their improved ability to express opinions and engage in meaningful dialogue. This highlights the positive impact of the method, particularly the workshops, in honing students' skills and fostering a collaborative and engaging learning environment.

By focusing on practical application and leveraging students' demonstrated talents, we create a more enriching and empowering educational experience. This approach allows students to assume the roles of both teacher and learner, broadening their perspectives and deepening their insights into various aspects of the subject. It not only enhances learning outcomes but also aligns with the principle of tailoring the curriculum to individual abilities, enabling students to specialize in areas of interest.

Our pedagogical approach eliminates the need for traditional final exams by evaluating students based on their work and performance using various criteria throughout the course. This shift means that final exams are only necessary for students who, for any reason, have been unable to participate in most class sessions, whether in person or online, and have instead relied on offline materials. For these students, it has not been possible to properly assess their abilities and talents during the regular course flow. Therefore, the final exam serves as a tool to evaluate these students' understanding and skills, ensuring a fair assessment of their capabilities.

Finally, it is important to emphasize that the collaborative nature of this educational approach is crucial for helping students develop essential skills such as teamwork, communication, and coordination. This approach encourages students to appreciate the advantages of learning from the diverse abilities and talents of their peers. These skills are vital not only for academic success but also for future career prospects. By building effective relationships and networks through collaboration, students can potentially create entrepreneurial opportunities after graduation, using their skills and knowledge to solve real-world problems and make a positive impact on society.

This methodology was tested across four courses over two semesters, at both the master's and Ph.D. levels, to evaluate its impact on learning outcomes and student satisfaction. The upcoming section will detail this implementation, including the data collection methods, analysis techniques, and key findings.

3. Details On Conducted Case Studies

The case study groups at the University of Tehran's School of Surveying and Geomatics Engineering comprised first-year graduate students specializing in a Master of Hydrography and a Ph.D. in Geodesy. The Hydrography students applied this methodology in three of their courses (two in the first semester and one in the second semester), while the Geodesy students implemented it in one of their courses during the second semester. In this section, we will go through the outcomes of those experiences.

Hydrography, a field that measures and describes the physical characteristics of water bodies and their surrounding land areas, plays a vital role in many applications such as safe navigation, coastal zone management, marine resource exploration, environmental protection, and disaster prevention. Geodesy, on the other hand, is the science of accurately measuring and understanding the Earth's geometric shape, orientation in space, and gravity field, as well as how these properties change over time. This field is fundamental for various applications including satellite navigation, mapping, and understanding sea level rise.

Although these students share a background in Surveying Engineering, they come from different universities with varying academic rankings and are new to master's-level hydrography and Ph.D.-level geodesy courses. The authors are responsible for teaching these students in four key courses over two consecutive semesters. For master's students, the courses include “Law of the Sea and Marine Cartography”, and “Tide and Tidal Currents” (during the Fall semester), and Marine Geodesy (during the Winter semester). For Ph.D. students, the course is titled “Reference Systems in Geodesy” (during the Winter semester). Each course spans 16 weeks, with classes held twice a week, each session lasting one and a half hours.

The “Law of the Sea and Marine Cartography” course explores both the legal and technical aspects of the sea and its boundaries (Schofield et al. 2019). It covers the methods and standards for producing nautical charts, which are vital for navigation, exploration, and management of marine resources. In this course, students learn about the principles and conventions of the Law of the Sea, the delimitation of maritime zones, the rights and obligations of coastal and flag states, as well as the resolution of maritime disputes (McDorman 2018). Moreover, they develop the skills and knowledge necessary to create and use nautical charts, essential tools in the domain of marine activities (Luis et al. 2016).

The “Tide and Tidal Currents” course delves into the complex phenomenon of tides, including their causes, characteristics, and diverse applications (Moreira et al. 2018). The course covers a wide range of topics such as the origin and variation of tides, methods for measuring and predicting tides, concepts of satellite altimetry, data corrections, the harmonic representation and analysis of tidal data, numerical modeling of tidal currents, and the impacts of tides on coastal and marine systems. Additionally, it includes Earth and Moon motions, astronomical approaches to tidal constituents, Legendre series expansion of tidal potential, and computations of mean sea level and sea surface topography. This comprehensive exploration equips students with a deep understanding of tides and their multifaceted influences on various aspects of coastal and marine environments (Zavala-Hidalgo et al. 2015).

The “Marine Geodesy” course introduces students to the principles and practices of hydrography, focusing on the physical characteristics of water bodies and their surrounding land areas. Topics covered include the physics of waves, sounding techniques, and the use of various sonar systems (single beam, multibeam, and side scan) (Reinking 2010). Students also learn about positioning systems such as Loran, Omega, and Global Navigation Satellite Systems (GNSS), as well as underwater positioning methods like USBL, SBL, and LBL (Guo et al. 2022). The course also covers the use of remotely operated vehicles (ROVs) and the application of general least squares and Kalman filter techniques in hydrographic operations (Reinking 2010).

The “Reference Systems in Geodesy” course, offered at the Ph.D. level, covers advanced topics such as Jacobi ellipsoidal coordinates, the solution of the 3-D Laplace differential equation, and the determination of reference systems for terrestrial planets (Hase 2014). Students explore the reference ellipsoid as the best fitting ellipsoid to the geoid, time variations of the reference ellipsoid and geoid's potential, and the reference gravity field (Drewes 2009). The course also addresses height and height datums, height datum unification, and the application of satellite altimetry in height datum determination (Guo et al. 2022). Additionally, students learn about map projections, deformation analysis, and strain analysis, providing them with a comprehensive understanding of geodetic reference systems and their applications (Hase 2014).

A. Evaluations and key findings

To assess the effectiveness and advantages of our methodology for enhancing students' learning outcomes, we conducted the following evaluations.

Evaluation 1: This assessment offers an overview of the students' performance in the above-mentioned four courses. The summary of this assessment, presented in Table 2, includes the number of topics within the course content, the percentage of topics collectively covered in the students' lectures, and the estimated percentage of knowledge acquired based on exam results. It is important to emphasize that the covered topics were achieved collectively by summing up the topics chosen by all individual students.

In the “Law of the Sea and Marine Cartography” course, a total of 9 topics were covered. The students' lectures encompassed 98% of these topics, with only one topic (details on chart content generalization) being partially addressed. The estimated percentage of knowledge acquired based on the exam results was 95%.

In the “Tide and Tidal Currents” course, 16 topics were included, covering the theory and practice of tide and tidal current prediction, analysis, and measurement. The students' lectures covered 90% of these topics, with some topics (tide prediction applications, tidal currents modeling) being skipped or briefly mentioned. The estimated percentage of knowledge acquired based on the exam results was 87%.

In the “Marine Geodesy” course, there were 22 topics in the list of content, with only three topics (practical application of hydrography in exploration application, underwater pipeline laying, and ship squat determination) not covered. These topics are samples from real professional applications and their omission does not harm the students' overall knowledge. The percentage of covered topics was approximately 86%. The overall score of the students was 96%.

In the "Reference Systems in Geodesy" course, from 17 topics in the table of contents, only three were not covered. These topics, which are related to the determination of the reference systems for terrestrial planets, the implicit function theorem and its application in various geodetic problems, and graphs and level sets and their relation with equipotential surfaces, are of secondary importance compared to the other topics. Considering the deeper knowledge that students acquired on the other topics, these omissions were deemed acceptable. The percentage of covered topics was approximately 82%. The average exam score of the students was 98%.

To understand the significance of the average exam scores, we need to consider the exam question formation and the marking scheme:

The exam questions in our courses cover all topics discussed in the lectures, without exception. Students who present a topic are expected to demonstrate a high level of understanding and answer the corresponding question correctly to receive the full score. Those who did not present the topic must still show a satisfactory level of understanding and answer the question adequately to achieve the full score.

Additionally, the mark of a student who presented a topic is influenced by how well their peers answered that question. This is calculated using the formula:

(Mark of the student for the topic they presented) × (number of peers with satisfactory answers + 1) ÷ (total number of students)

In this way, a student who presented a topic can achieve the full score if all their peers provide satisfactory answers to the corresponding question, reflecting the effectiveness of their teaching.

The final exam and its grading system have been intentionally designed and integrated into our teaching methodology to further motivate students to participate in discussions and presentations, thereby enhancing their teamwork. This approach encourages students to teach one another, deepening their understanding of the subject and improving their learning as they share knowledge with peers. Additionally, it fosters a collaborative environment where students may organize workshops or exercises to assess their peers' comprehension of the material.

Thus, our teaching methodology's final exam diverges from traditional approaches. Instead of merely serving as an evaluation tool, it becomes a crucial part of our teaching strategy, enhancing students' communication skills and promoting collective knowledge growth. Effective knowledge transfer occurs when students have mastered the subject matter, leading to proficiency in their chosen topics.

In conclusion, as we refer to Table 2, it is evident that a significant portion of the course topics has been covered across all case study courses. Students were informed that they did not need to cover all topics and could focus on those of greatest interest to them. Nevertheless, with guidance from professors, students collectively managed to cover a substantial part of the course content through their chosen topics.

Furthermore, the flexibility of our teaching methodology, which creates a stress-free learning environment, has proven to be highly successful. Even though students are allowed to selectively focus on topics of interest, the average marks in the case study courses, based on the specified marking formula, indicate a very satisfying level of learning. This outcome highlights the effectiveness of our innovative teaching strategy, which surpasses traditional education by promoting teamwork, deep learning, and mastery of subjects.

Additionally, this approach increases the likelihood that students will develop their own joint ventures in the future. By allowing students to focus on their individual interests and deepen their expertise in those areas, they can collectively form powerful teams. The students educated in this way are likely to remain together, continuing to benefit from teamwork and building groups that leverage the collective abilities of each individual, creating a well-rounded and complete team.

Table II :
Summary of Course Topics Coverage and Learning Assessment Through Final Exam.

Course	Number of topics included in the list of contents	Percentage of covered topics by the students' lectures	Estimated learned percentage according to exam
Law of the Sea and Marine Cartography	9	98	95
Tide and Tidal Currents	16	90	87
Marine Geodesy	22	86	96
Reference Systems in Geodesy	17	82	98

Evaluation 2: For the second evaluation of our methodology, we present the comprehensive performance of all students in the mentioned courses. This final evaluation reflects the abilities and progress of students in various aspects, based on continuous monitoring by the teaching assistant. Here, we present the final results of these assessments for all students who participated in the mentioned courses, identified by numbers instead of actual names. These evaluations include two courses from the Fall semester of 2023 and two courses from the Spring semester of 2024.

Furthermore, by presenting the performance of all students without exception, we can identify those who have not achieved successful evaluations. This allows us to discuss the students who have not shown satisfactory progress and to identify areas of our methodology that require further improvement.

We begin with the overall performance of students in two graduate courses offered in the Fall 2023 semester: "Marine Cartography and Law of the Sea" and "Tide and Ocean Currents". Table 3 presents the final performance outcomes of the students, highlighting several key points. As shown in the second column of the table, students explored a wide range of research topics selected according to their interests. The table also evaluates students based on several competencies, including Digital Literacy and Technological Proficiency, Analytical and Critical Thinking, Problem-Solving and Presentation Skills, Collaborative Competence, and Academic Achievement. By considering these metrics, we aim to demonstrate how our educational approach not only develops academic knowledge but also equips students with the essential skills needed for a successful professional career.

Each of these courses included 32 sessions, with eight conducted in a workshop format. These workshops provided opportunities for teamwork and collective learning, and taught students how to break down their topics into simpler parts, approaching them as problems to be solved. Additionally, students learned how to effectively use internet resources and AI tools for this purpose.

The variation in scores across different competencies for each student highlights individual strengths and areas for improvement. For example, Student 4 consistently achieves high scores across all metrics, indicating well-rounded proficiency. In contrast, Student 11 has lower scores, suggesting the need for additional support or an investigation into personal reasons that may have affected performance. Eventually, Student 11 withdrew from the study due to personal reasons, which had already begun to affect their academic performance during the semester.

Incorporating collaborative competence as a metric highlights the importance of teamwork and communication skills in our methodology, demonstrating our commitment to preparing students for collaborative work environments. Topics such as “Techniques in Satellite Altimetry”, “Nautical Charting”, and “Modeling Variations in Caspian Sea Levels” emphasize the practical, real-world applications of theoretical knowledge.

It is worth noting that in the workshops held near the end of the semester, students identified their potential and effectively leveraged the strengths of their team members when distributing tasks within their groups. Interestingly, their choices closely matched our assessments of their abilities. In instances where there were deviations, the teaching assistant provided guidance to ensure optimal job distribution for maximum efficiency.

Table III :
Overall Student Performance in “Marine Cartography And Law f The Sea” and “Tide and Ocean Currents” Courses (fall 2023).

Student	Research Topics	Learning Engagement	Digital Literacy and Technological Profici ency	Analytical and Critical Thinking	Problem-Solving and Presentation Skills	Collaborative Competence	Academic Achievement
1	1. Differences Between Acoustic and Radar Tide Gauges 2. Caspian Sea Agreement 3. Unification of Height Datums between Kronshtadt and the Caspian Sea 4. Modeling Variations in Caspian Sea Levels	4	3	4	5	4	4
2	1. International Regulations on Marine Pollution 2. International Compensation Fund for Oil Pollution 3. Waste Pollution 4. Sanchi Tanker Incident 5. Oceanic Tidal Currents	4	2	3	3	5	3
3	1. Differences Between Various Maps 2. Satellite Altimetry Techniques 3. Oil and Gas Resources in Shared Basins 4. Instruction on Nautical Charts for Mariners 5. LIDAR Technology 6. Nautical Charts of Iran 7. Oil Pollution Issues in Iran 8. Coding for Rayleigh Condition	4	3	2	4	2	4
4	1. Formula for Tidal Potential 2. Drawing the Equidistant Line between Iran and Oman 3. Agreement on Maritime Boundary Delimitation between Iran and Pakistan 4. Calculation of Tidal Potential at Various Locations 5. Tidal Forces 6. Harmonic Analysis of Tides 7. Equidistant Line between Iran and Pakistan	5	5	4	5	5	5
5	1. Height Datum of the Caspian Sea 2. Reasons for Variations in Height Datums Among Countries 3. Techniques in Satellite Altimetry 4. Maritime Boundary Coordinates of the Iran-Pakistan Agreement5. Border Line and Territorial Area between Iran and Azerbaijan 6. Maritime Straits	4	5	4	4	4	4
6	1. Internal Bays 2. Historical Estuaries 3. Nautical Charting 4. Techniques in Satellite Altimetry 5. Islands and Archipelagic States 6. Determination of Mean Sea Level	5	3	3	3	3	4
7	1. United Nations Convention on the Law of the Sea (UNCLOS) 2. Techniques in Satellite Altimetry 3. Persian Gulf Basin and Territorial Waters 4. Crimes Related to Marine Pollution	4	2	5	4	4	4
8	1. Nautical Mile and the Three Islands 2. Jason Satellite Altimetry Mission Overview 3. Introduction to Software for Tidal Modeling	4	4	4	4	4	5
9	1. Legislation on Environmental Issues 2. Artificial Islands and Different Types of Maps	3	3	3	4	3	3
10	1. Types of Bays 2. Necessary Corrections for Data Records of Various Tide Gauges 3. Nautical Charting	5	3	3	4	3	4

	4. International Hydrographic Organizations 5. Selection Criteria for Tide Gauge Sites 6. International Maritime Organization (IMO) Convention						
11	1. Artificial Islands in an International Context	2	2	2	2	2	2

In the following semester, we introduced two additional courses using our established methodology. We present the outcomes for these courses separately, as one was offered to Ph.D. students and the other to Master's students. Notably, most of the Master's students had previously taken two other courses in the prior semester and were already familiar with the method. However, three students from other disciplines, who joined this course, were new to the approach. Conversely, the Ph.D. students were encountering the method for the first time, requiring a few weeks to help them acclimate to the expected classroom dynamics. Tables 4 and 5 provide detailed insights into student performances for these two courses during the Spring 2024 semester.

We begin with Table 4, which details the outcomes of implementing our teaching methodology for Master's students in the graduate course "Marine Geodesy". While most of these students had prior experience with this method from previous courses, the class was conducted in a workshop format—with over 20 sessions held this way—with the students' consent and the instructor's discretion. Notably, students numbered 9, 11, and 12 in Table 4 joined this course from other disciplines and had not previously encountered this method.

Based on the information provided in the table, the following conclusions can be drawn:

1. Adaptation of New Students: Students new to the teaching method (students 9, 11, and 12) initially struggled but showed varying degrees of improvement over time. Based on our experience, it typically takes a few sessions to gradually familiarize students with the method. There is no need to introduce all the details of the methodology at once; instead, students should become acquainted with the details practically and progressively. Therefore, the time required for students 9, 11, and 12 to adapt is quite normal and aligns with our expectations for students encountering our methodology for the first time.

2. Engagement and Improvement: Most students demonstrated high levels of engagement and improvement, particularly in critical thinking, problem-solving, and collaborative skills. This indicates that the workshop format and hands-on approach were effective in enhancing these competencies.

3. Digital Literacy and Technological Proficiency: There is a noticeable variation in digital literacy and technological proficiency among students. While some students demonstrated advanced skills (e.g., students 6 and 7), others exhibited moderate proficiency (e.g., students 2 and 3). This indicates a need for differentiated instruction and additional resources to support students with lower proficiency levels.

Furthermore, it is essential to recognize that students possess diverse abilities, and uniform performance across all metrics should not be expected. In such cases, we aim to identify and nurture other potentialities and talents in students who may lag in certain areas. We believe that when a student struggles in one aspect, they often excel in others. It is crucial to discover and develop these strengths while also improving our methods to help those who have difficulty in certain areas to improve as much as possible.

4. Challenges for Interdisciplinary Students: Students from other disciplines (students 9, 11, and 12) faced more significant challenges, particularly in analytical and critical thinking, and digital literacy. This demonstrates the effectiveness of our methodology, as those who had previously attended two other courses using our approach performed much better than those new to it. Nevertheless, it also underscores the importance of providing interdisciplinary support.

Due to the fixed time frame of the semester, it was not possible to fully address and bridge these gaps. This highlights another potential limitation of our methodology: the traditional semester setup is not ideally designed for a teaching approach like ours. Our methodology requires more time than the usual classical semester period to be fully effective for all students. Therefore, its implementation within the standard lecturing hours can be considered a limitation.

5. Overall Academic Performance: Despite initial biases and adaptation periods, the majority of students achieved high academic performance by the end of the sessions. This underscores the

success of the teaching methodology in fostering academic achievement.

6. Collaborative Competence: High scores in collaborative competence across most students indicate that the workshop format effectively promoted teamwork and peer learning, which are crucial skills in both academic and professional settings.

The doctoral students enrolled in the “Reference Systems in Geodesy” course during the Spring 2024 semester were also introduced to this teaching methodology. As this approach was entirely new to them, they initially displayed significant bias and required time to adapt during the first four sessions. However, after these initial sessions, they demonstrated substantial improvement. By the eighth session, they had fully acclimated to the method.

Table 5 presents the outcomes of this implementation and evaluates students across several competencies, including Digital Literacy and Technological Proficiency, Analytical and Critical Thinking, Problem-Solving and Presentation Skills, Collaborative Competence, and Academic Achievement. The table shows that the doctoral students engaged in a wide range of advanced and specialized research topics. This was achieved through a flexible approach to the syllabus, tailored to the students' interests, without imposing any specific requirements on them.

The initial bias and subsequent improvement suggest that students can adapt to new teaching methods, given time and support. This adaptability is crucial for their future research and professional endeavors. The high scores across various competencies for most students indicate strong engagement and proficiency in their research areas. For example, Student 1 and Student 3 show consistently high scores, suggesting a high level of competence and readiness for advanced research.

The inclusion of collaborative competence as a metric highlights the importance of teamwork and communication skills, preparing students for collaborative research environments. Research topics such as “Establishing Reference Frames” and “Inertial Navigation Systems” emphasize the practical application of theoretical knowledge, which s essential for advanced research in geodesy.

Table IV :
Outcomes of Implementing the Teaching Methodology For Master's Students in the Graduate Course "Marine Geodesy" (Spring 2024)

Student	Research Topics	Learner Engagement	Digital Literacy and Technological Proficiency	Analytical and Critical Thinking	Problem-Solving and Presentation Skills	Collaborative Competence	Academic Achievement
1	1. Calculations Involving IMU, GPS, and INS 2. Utilizing LIDAR Technology 3. Kalman Filter Modeling	4	4	4	5	4	4
2	1. Calculating Depth Using Gravimetric Data and Inverse Solutions of Newton's Integral	5	4	3	4	5	4
3	1. Determining Depth Using Sounding Techniques 2. Essential Adjustments for Echo Sounders 3. Positional Errors from Vessel Movement 4. Inertia Principles in Inertial Measurement Units (IMUs) 5. Navigational Positioning with LORAN and Omega Systems	5	4	3	5	5	5
4	1. Underwater Positioning with the LBL Technique 2. Techniques for Underwater Positioning 3. Different Positioning Methods 4. Combining Underwater Positioning Techniques 5. Benefits of Integrating IMS and INU for Navigation	5	4	4	5	5	5
5	1. Sound Velocity Profiler (SVP) 2. Refraction and Its Effect on Sounding 3. Kalman Filter	5	4	4	5	5	5
6	1. Devices for Measuring Currents 2. Navigational Aid Systems 3. Lagrangian and Eulerian Methods for Current Measurement4. Remotely Operated 4. Underwater Vehicles (ROVs)	5	5	5	5	5	5
7	1. Wave Physics 2. Synthetic Aperture Radar (SAR)	5	5	5	5	5	5
8	1. Bathymetric Sonar: Essential Instruments and Calibration 2. Single-Beam Echo Sounder (SBES) 3. Multi-Beam Echo Sounder (MBES) 4. Side-Scan Sonar (SSS) 5. Operational Principles of Multi -Beam Systems	4	3	5	5	5	5
9	1. Geothermal Potential of Hot Springs	4	4	2	5	2	4
10	1. Planning Hydrographic Survey Operations for Bathymetric Mapping 2. Designing Sounding Lines for Harbor Bathymetric Surveys 3. Bathymetric Control Lines 4. Correlation of Sounding Lines with Seafloor Slope 5. Single-Beam and Multi-Beam Echo Sounder Technologies	5	5	5	5	5	5
11	1. Inertial Navigation Systems (INS) with North - Seeking Gyroscopes in Satellites 2. Wave Physics	5	3	3	4	4	5
12	1. Geophysical Exploration Applications in Marine Geodesy	3	2	1	2	2	2

Table V : Outcomes And Competency Evaluations of Doctoral Students in "Reference Systems in Geodesy" (Spring 2024)

Student	Research Topics	Learner Engagement	Digital Literacy and Technological P roficiency	Analytical and Critical Thinking	Problem-Solving and Presentation Skills	Collaborative Competence	Academic Achievement
1	1. Establishing Reference Frames (International Terrestrial Reference Frame - ITRF) 2. The Role of VLBI and SLR Measurement s in the Establishment of ITRF	5	5	5	5	4	5
2	1. Inertial Navigation Systems (INS) 2. Biological Inertial Navigation Systems (BINS) in Animals	5	5	3	5	3	4
3	1. GRACE Satellite Data 2. Geopotential Models and Their Influence on Geodetic Reference Systems 3. Precise Satellite Orbit Determination 4. Bruns' Formula 5. Importance of Satellite Orbit Determination in Geodesy 6. Geoid's Effect on Geodetic Reference Systems	5	5	4	5	4	5

Evaluation 3: To assess the impact of this approach on students' learning outcomes, we conducted a survey with the students who enrolled in the courses during the Fall 2023 semester. The survey aimed to capture the students' opinions on how effective this approach was in terms of enhancing their skills, motivation, and engagement. Students responded using a Likert scale, and we analyzed the results using descriptive statistics. The survey questions are attached in the appendix. The main findings of the survey are as follows:

1. Difference from Traditional Teaching Approaches: 67% of students strongly agreed that our teaching method was different from traditional ones, with 16.5% agreeing and 16.5% neutral.

2. Improvement in Learning Abilities and Self-Assurance: 50% of students agreed and 50% strongly agreed that the method helped improve their learning and professional development.

3. Challenge in Adjusting to the Approach: 16.5% found it very challenging, 8% found it somewhat challenging, 42% were neutral, 16.5% found it somewhat easy, and 16.5% found it very easy to adapt to the method.

4. Role of Professor and Classmates in Overcoming Challenges: 67% of students agreed and 25% strongly agreed that they received adequate support from their professor and peers, with 8% neutral.

5. Interference with Other Courses: 16.5% strongly disagreed, 42% disagreed, 25% were neutral, and 16.5% agreed that their presentations interfered with their performance in other courses.

6. Increase in Learning Skills and Self-Confidence: 25% of students agreed and 42% were neutral, while 25% strongly agreed and 8% disagreed that the method enhanced their learning skills and confidence.

7. Contribution of Presentations to Comprehension and Proficiency: 75% of students agreed that they learned a lot from their presentations and the feedback they received, with 8% neutral and 8% strongly agreeing.

8. Effectiveness of Feedback from Professor: 67% of students strongly agreed and 25% agreed that the feedback from their professor was effective, with 8% neutral.

9. Enhancement of Perspective on Collaboration and Teamwork: 47% of students strongly agreed and 34% agreed that the method improved their attitude towards teamwork and communication, with 16.5% neutral and 8% disagreeing.

10. Facilitation of Understanding of Work Environment and Professional Expectations: 34% of students agreed and 50% were neutral that the method helped them understand the real work environment and expectations, with 16.5% disagreeing.

11. Impact on Outlook and Motivation for Career Opportunities: 50% of students agreed and 25% strongly agreed that the method influenced their attitude toward their future career, with 16.5% neutral and 8% disagreeing.

12. Contribution of Peers to Future Professional Endeavors: 34% of students agreed and 34%

strongly agreed that their classmates could become future colleagues based on the mutual respect and trust developed through this teaching method, with 16.5% neutral and 16.5% disagreeing.

In conclusion, the survey results indicate that our teaching methodology significantly enhances students' learning outcomes, motivation, and engagement, while also preparing them for their future careers.

Conclusion and Final Discussions

In this study, we introduced a teaching methodology called "flexible education", which focuses on personalized learning and skill development. Our comparative review of traditional and "flexible education" highlights the superior strengths of our approach over the traditional one. "Flexible education" offers students access to a wide range of online resources, encourages engagement through presentations and public speaking, aligns the curriculum with labor market demands, and involves continuous evaluation of student progress. This approach not only addresses the shortcomings of traditional education but also significantly enhances students' learning outcomes, motivation, and overall academic performance.

This methodology involves students in selecting study topics, conducting independent research, and presenting their findings to the class, with the professor providing feedback and support. It emphasizes active learning, collaboration, and student responsibility, with the professor and teaching assistant playing crucial roles in facilitating the approach, particularly focusing on feedback and student engagement.

To assess the effectiveness and benefits of our methodology, we conducted several evaluations, including analyzing the performance of master's students in three hydrography engineering courses and one Ph.D. course in geodesy. The flexibility of our teaching methodology, which creates a stress-free learning environment, has proven highly successful. Despite allowing students to focus selectively on topics of interest, the average marks in the case study courses indicate a very satisfying level of learning. This outcome underscores the effectiveness of our innovative teaching strategy, which surpasses traditional education by promoting teamwork, deep learning, and mastery of subjects.

The evaluation of our methodology through its adaptation to four graduate courses has highlighted several important findings. Students new to this teaching method initially struggled but showed improvement over time. It typically takes a few sessions to familiarize students with the method. Additionally, there is a noticeable variation in digital literacy and technological proficiency among students. Some demonstrated advanced skills, while others exhibited moderate proficiency, indicating a need for differentiated instruction and additional resources.

Students from other disciplines faced significant challenges, particularly in analytical and critical thinking, and digital literacy, compared to those familiar with our method. This underscores the importance of providing more support to these students, which may be difficult to fully address within the fixed semester timeframe. Furthermore, the traditional semester setup is not ideally designed for our teaching approach. Our methodology requires more time than the usual semester period to be fully effective, making its implementation within standard lecturing hours a limitation. Additionally, students who do not fully engage with the methodology can interfere with the overall learning environment, affecting the progress of others.

Despite these areas needing more attention, the majority of students achieved high academic performance by the end of the sessions, underscoring the success of the teaching methodology in fostering academic achievement. High scores in collaborative competence across most students indicate that the methodology, especially in its workshop format, can effectively promote teamwork and peer learning, which are crucial skills in both academic and professional settings.

Additionally, we surveyed students to gather their opinions on the approach. The survey results show that our teaching methodology significantly enhances students' learning outcomes, motivation, and engagement, while also preparing them for their future careers. Moreover, this approach increases the likelihood of students developing joint ventures in the future. By focusing on their individual interests and deepening their expertise, they can form powerful, well-rounded teams. This collaborative environment enhances their academic and professional skills while fostering a sense of community and mutual support, essential for long-term success.

The "flexible education" approach is applicable to any discipline. Although we have discussed it in the context of three graduate hydrography courses and one Ph.D. course due to our expertise and current teaching responsibilities, the core principles—flexibility in participation modes and topic selection, peer teaching, and collaborative learning—are universally applicable. This methodology can be adapted to meet the specific needs and contexts of various fields or subjects, ensuring that the fundamental idea of personalized and flexible learning remains consistent.

Future Works

In this study, we introduced a teaching approach that leverages the benefits of learning through teaching and addresses the diverse needs of learners. Moving forward, we recommend its adoption by other professors and encourage the exchange of insights to refine the implementation plan. Based on our findings, we propose a phased implementation of this method, allowing learners to focus on one topic at a time to prevent interference and cognitive overload from other subjects.

Appendix

In this appendix, we present survey data reflecting the perspectives of 20 students who participated in the lectures. The responses indicate the percentage of answers corresponding to the scores on the Likert Scale (given in parentheses).

1. Difference from Traditional Teaching Approaches:

   16.5% (2), 16.5% (3), 67% (5)

2. Improvement in Learning Abilities and Self-Assurance:

   50% (4), 50% (5)

3. Challenge in Adjusting to the Approach:

   16.5% (1), 8% (2), 42% (3), 16.5% (4), 16.5% (5)

4. Role of Professor and Classmates in Overcoming Challenges:

   8% (3), 67% (4), 25% (5)

5. Interference with Other Courses:

   16.5% (1), 42% (2), 25% (3), 16.5% (4)

6. Increase in Learning Skills and Self-Confidence:

   8% (1), 25% (2), 42% (3), 25% (4)

7. Contribution of Presentations to Comprehension and Proficiency:

   8% (2), 8% (3), 75% (4), 8% (5)

8. Effectiveness of Feedback from Professor:

   8% (3), 25% (4), 67% (5)

9. Enhancement of Perspective on Collaboration and Teamwork:

   8% (2), 16.5% (3), 34% (4), 47% (5)

10. Facilitation of Understanding of Work Environment and Professional Expectations:

    16.5% (1), 50% (3), 34% (4)

11. Impact on Outlook and Motivation for Career Opportunities:

    8% (1), 16.5% (3), 50% (4), 25% (5)

12. Contribution of Peers to Future Professional Endeavors:

    16.5% (2), 16.5% (3), 34% (4), 34% (5)

Acknowledgment

We sincerely acknowledge the valuable feedback and comments from three anonymous reviewers, which significantly improved this manuscript.

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