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Redefining learning: student-centered strategies for academic and personal growth

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As the landscape of higher education continues to evolve, institutions must adapt to meet the changing needs of prospective graduate students. This article explores the implications of student-centered strategies on the academic and personal growth of graduate science students. The traditional teacher-centered approach, while effective in conveying foundational knowledge, has been criticized for hindering the development of critical thinking, creativity, and problem-solving skills. In contrast, the student-centered approach shifts the focus to learners, encouraging active participation and fostering essential skills needed to address modern scientific challenges. The teaching concepts, “for the student,” “of the student,” and “by the student” emphasize inclusivity, peer collaboration, and encouraging students to take ownership of their education. A prime example of the success of this approach is the “Molecular Basis of Cancer” course, which transitioned from a traditional teacher-centered model to a student-centered one. This shift has allowed students to engage more deeply with complex scientific concepts, fostering independent learning, peer-led discussions, and collaborative research. The results of this transition are evident not only in improved academic performance but also in significant scientific outputs, such as published research articles co-authored by students. By encouraging critical inquiry, creativity, and a professional attitude, the course enables graduate students to navigate real-world scientific challenges more effectively. This case study highlights the accomplishments of student-centered model while identifying areas for further improvement in teaching practices and curriculum design. It underscores the importance of student-centered teaching in shaping future scientific leaders by providing a more balanced, dynamic, and inclusive learning environment for graduate students in science-education. As education continues to evolve, blending traditional methods with student-centered approaches will be key to creating engaging and empowering educational experiences that meet the demands of both students and the ever-advancing fields of science and technology.

KEYWORDS

student-centered-approach, critical thinking, collaborative learning, curriculum design, scientific challenges, active participation

1 Introduction

The need for an educational paradigm that fosters self-thinking, innovation, independent learning, and professional attitudes is increasingly recognized in today’s dynamic world. The traditional teacher-centered approach in scientific education has long been a hallmark of classroom instruction (Mladenovici et al., 2022). In this pedagogical model, the teacher

assumes a central role as the primary source of knowledge and authority in the learning process (Woods and Copur-Gencturk, 2024; Murphy et al., 2021). Teachers structure the curriculum, prepare and deliver lectures, and provide explanations, demonstrations, and assessments to their students. Students, on the other hand, are positioned as passive recipients of information without cultivating the critical thinking, problem-solving skills, and creativity essential for success in contemporary scientific endeavors. Their primary responsibility is to listen, take notes, and absorb the content presented by the teacher. Interactions between students and the teacher are often limited, with classroom dynamics characterized by a one-way flow of information. This approach heavily relies on teacher-led lectures as the primary mode of content delivery, with textbooks and supplementary materials used to reinforce the material covered in class. The curriculum tends to be linear and pre-determined, leaving limited room for student exploration or deviation from the prescribed syllabus. While the traditional teacher-centered approach can effectively convey foundational knowledge, it has faced criticism for potentially fostering rote memorization over deep understanding and for not adequately preparing students with the critical thinking and practical skills often required in real-world scientific research and professional practice (Kálmán et al., 2020). As education evolves, many institutions are increasingly adopting more student-centered and active learning methods to better equip students for the challenges and complexities of modern science and technology (Klegeris, 2021; Dogani, 2023).

Teaching for self-thinking, innovation, independent learning, and a professional attitude represents a comprehensive educational approach that extends beyond traditional methods (Mladenovici et al., 2022). This approach empowers students with essential skills and attitudes vital for success in a rapidly changing world. It emphasizes the development of critical thinking, problem-solving, and creativity, encouraging students to analyze, question, and innovate. Open-mindedness and a willingness to take risks are fostered, recognizing that diverse perspectives and adaptability are key to innovation (Gamage et al., 2021). Independent learning skills, such as self-direction, resourcefulness, and a commitment to lifelong learning, are cultivated, enabling students to take charge of their education and thrive in dynamic settings (Tekkol and Demirel, 2018). Additionally, a professional attitude is integral, emphasizing responsibility, ethical conduct, effective communication, and the ability to lead and collaborate with others. In essence, this approach equips students with not only academic knowledge but also the practical skills and mindset necessary for successful and impactful lives in their future careers and communities.

Despite the established importance of innovative educational practices, there remains a notable gap in the literature regarding effective implementations of student-centered strategies in scientific education. Specifically, while various studies have argued for a shift toward more active learning methodologies, comprehensive frameworks that outline how these pedagogical shifts impact graduate science students' academic and personal growth remain underexplored. Currently, most existing research focuses on theoretical discussions of student-centered pedagogies however lacks empirical evidence and case studies explicitly detailing their application and effectiveness in scientific disciplines, particularly at the graduate level. This review article addresses the critical issue of how traditional teacher-centered science education may hinder the

development of essential skills in students, which are increasingly needed in both academic and professional realms. Additionally, this review provides current literature on student-centered strategies and present a case study from the "Molecular Basis of Cancer" course which successfully transitioned from a traditional teacher-centered model to a student-centered framework to illustrate how these approaches can enhance both academic performance and personal growth in graduate science students. By highlighting this case, we aim to provide insights that can inform educators and institutions about the potential benefits of adopting more interactive, student-focused teaching methods in scientific education.

2 Historic overview

The historical development of traditional teaching methods spans centuries and reflects the evolution of educational philosophies, societal needs, and technological advancements (Uiboleht et al., 2018). Traditional teaching, characterized by its teacher-centered approach, has been a cornerstone of formal education (Chaika, 2024). In antiquity, education in civilizations like Mesopotamia, Egypt, and Greece relied on oral transmission of knowledge through lectures and discussions. During the medieval period, Christian monastic schools played a pivotal role in preserving and disseminating knowledge, emphasizing religious education and the Latin language (Guijarro González and González, 2008; Haskins, 1926). The Renaissance brought a renewed interest in classical learning and the establishment of universities, formalizing teacher-led lectures. The Enlightenment era emphasized reason in education. The Industrial Revolution led to mass education systems in the 19th century, formalizing classrooms and textbooks with teachers as authoritative figures (Education in the UK, n.d.). The 20th century saw the refinement and expansion of traditional methods, with technology like chalkboards and projectors enhancing teaching. In the late 20th century, digital learning resources and educational theories like constructivism challenged the teacher-centered approach, emphasizing active student participation and critical thinking (Almulla, 2023). While traditional teaching methods have advantages in transmitting foundational knowledge, they have faced criticism for potentially limiting critical thinking. As education evolves, there is a growing emphasis on the balanced approaches that integrate traditional methods with active, student-centered pedagogies (Goodwin, 2024).

Traditional teacher-centered approaches in education, though widely practiced, have faced significant criticisms and limitations (Mladenovici et al., 2022). A key critique is that these methods often promote passive learning, with students primarily receiving information from teachers through lectures and demonstrations, leading to reduced engagement and motivation. Critical thinking skills may not be sufficiently developed as traditional approaches tend to prioritize rote memorization over analytical thinking. Additionally, these methods may lack personalization, leaving little room for accommodating diverse learning styles and individual needs. Creativity and innovation can be stifled, and opportunities for meaningful student-to-student interaction and collaboration may be limited. Emphasis on summative assessments may measure memorization rather than deeper understanding, and the approach may exacerbate educational inequities. Critics argue that traditional methods might not adequately prepare students for the complex

challenges they'll face in their future careers, which often require adaptability and problem-solving skills (Alsaleh, 2020). Despite these criticisms, traditional approaches have their place, particularly for imparting foundational knowledge, but many educational institutions are moving toward more balanced and student-centered methods to address these limitations and foster a more engaging and effective learning experience (Goodwin, 2024).

3 Novel student-centered teaching approach

Student-centered teaching approaches prioritize the needs, interests, and learning styles of students, fostering an environment where they take an active role in their education (Dogani, 2023; Bremner, 2021; Darsih, 2018; Meng et al., 2019; Neumann, 2013; Starkey, 2019). The three teaching approaches, “for the student, of the student, and by the student,” each offer unique perspectives on student-centered education. “Teaching for the student” prioritizes tailoring education to individual student needs and learning styles, promoting inclusivity and addressing learning gaps (Garrett, 2008). Moreover, it ensures that every student, regardless of their background or learning abilities, finds a path to success. In this approach, teachers adapt their methods to ensure that each student can succeed, fostering a sense of equity and support in the classroom. In doing so, they not only bridge learning gaps but also cultivate a sense of belonging, fostering resilience and confidence among students. “Teaching of the student” recognizes the value of incorporating students’ diverse backgrounds, experiences, and perspectives into the learning process (Kerimbayev et al., 2023). It encourages collaborative learning and community building by valuing students’ voices and contributions, making the educational experience richer and more relevant. Lastly, “teaching by the student” empowers students to take an active role in teaching and learning, emphasizing peer-led instruction, presentations, and group projects (Uiboleht et al., 2018; Kerimbayev et al., 2023). This approach not only develops leadership and communication skills but also reinforces the idea that education is a dynamic, collaborative endeavor. Together, these approaches represent a shift toward more holistic, student-centered pedagogies that aim to create engaging, inclusive and empowering learning environments for students.

The teaching approaches “for the student, of the student, and by the student” represent distinct paradigms in education that prioritize student engagement, self-thinking, innovation, independent learning, and the cultivation of a professional attitude (Schweisfurth, 2015). These approaches are student-centered and seek to empower learners to take an active role in their education. Here’s a comprehensive overview of each approach in the context of these educational objectives.

3.1 Teaching “for the student”

The “for the student” approach is a holistic educational philosophy that focuses on recognizing and addressing the unique needs, interests, and learning styles of each individual learner. It rejects the traditional one-size-fits-all model in favor of embracing the diverse backgrounds, experiences, and preferences that each

student brings to the classroom (Bondie et al., 2019). This approach begins with the understanding that every student enters with distinct characteristics that influence how they learn best. Therefore, teachers must be adaptable, modifying both educational content and teaching methodologies to suit individual needs. For instance, while some students may grasp concepts more effectively through visual aids, others may excel in kinesthetic or auditory learning environments (Asikainen and Gijbels, 2017; Smarandache et al., 2022; Stover and Holland, 2021). Acknowledging these differences allows educators to implement a variety of instructional strategies, ensuring that every student has an optimal learning experience.

In addition to promoting personalized learning, the “for the student” approach empowers learners by granting them ownership over their educational journeys (Baeten et al., 2010). When students are allowed to select assignment topics that align with their interests, their motivation and engagement increase significantly. This autonomy fosters a sense of investment in their learning, encouraging them to take an active role in shaping their educational experiences. Instead of passively receiving knowledge, students become active participants, driving their learning based on what genuinely excites and challenges them. This approach also addresses the varying academic levels within a classroom, allowing for differentiated instruction that meets each student where they are. By providing personalized support for those who require it and offering advanced material for those ready for a challenge, educators can help ensure that all students experience meaningful academic growth (Elen et al., 2007).

Moreover, the “for the student” model enhances students’ critical thinking and investigative skills. By promoting inquiry-based learning, students are encouraged to explore, question, and analyze information, which helps cultivate independent thought and problem-solving capabilities. This model nurtures independence by involving students in decision-making processes related to their learning, such as selecting topics or establishing learning goals. As students learn to assess their progress and reflect on their achievements, they develop competencies that are not only vital for academic success but also essential for navigating real-world challenges (Elen et al., 2007; Drew, 1998). Overall, the “for the student” approach fosters a dynamic and individualized learning environment that supports personal growth, promotes motivation and participation, and equips students with the tools necessary for lifelong learning and future success.

Central to the “for the student” approach is the **emphasis on self-thinking and innovation**. This model encourages students to engage critically and creatively with their education, moving beyond rote memorization to foster a mind-set of inquiry. Students are motivated to ask questions, seek answers independently, and challenge their own understanding of complex topics. By promoting a culture of exploration, this approach helps students investigate, analyze, and engage with concepts in a way that stimulates their intellectual curiosity. The freedom to explore concepts independently empowers students to develop valuable problem-solving skills and the confidence needed to tackle challenges with creativity and persistence. They learn to navigate difficulties, reflect on their mistakes, and use these experiences to enhance their understanding. The “for the student” model also encourages students to propose innovative solutions to real-world problems, thereby sharpening their critical thinking skills and fostering their ability to think outside the box.

The “for the student” approach also significantly enhances **independent learning** by emphasizing self-directed and autonomous education. This philosophy provides students with the resources, guidance, and opportunities necessary to take control of their learning journeys. Empowering students means they actively shape their educational experiences, fostering a sense of responsibility and commitment to their studies. A crucial aspect of this independence involves setting personal academic goals, which helps students cultivate motivation and purpose. By defining their objectives, they can focus their efforts and measure their progress effectively.

Effective time management is another critical component of independent learning. Students learn to create schedules, prioritize tasks, and meet deadlines, cultivating discipline and responsibility that extends beyond the classroom. The approach encourages resourcefulness by prompting students to seek information from various sources, such as online platforms, libraries, and peer discussions, thus broadening their knowledge base and developing essential research skills. Furthermore, self-understanding is emphasized, with students encouraged to recognize their strengths, weaknesses, and preferred learning styles, allowing them to tailor their learning experiences to better suit their needs.

The “for the student” approach also plays a vital role in enhancing both **cognitive and metacognitive skills**, significantly enriching students’ overall learning experiences (Meyer et al., n.d.; Tezer, 2024). Cognitive skills are developed through strategies that promote problem-solving abilities, such as constructing informal rules for tackling challenges. Students learn to classify information based on specific criteria, which aids in organizing and synthesizing knowledge. Hypothesis formation is another key skill, as students are encouraged to propose and test hypotheses, deepening their understanding of scientific principles. Logical reasoning skills are honed as they assess situations, draw conclusions, and make evidence-based decisions.

Simultaneously, metacognitive skills are nurtured through reflection on learning processes and outcomes, enabling students to identify effective strategies and areas for improvement (Tezer, 2024). This self-reflection fosters a growth mind-set, empowering students to adapt their learning approaches as necessary. Monitoring their progress becomes a regular practice, helping them stay on track to achieve their academic goals. Engaging in self-assessment allows students to evaluate their understanding and mastery of subjects, promoting ownership of their learning and encouraging lifelong learning habits (Andrade, 2019).

In addition to academic growth, the “for the student” approach significantly contributes to the development of a **professional attitude** among students. It emphasizes personal responsibility, ethical conduct, and a commitment to lifelong learning, enabling students to take ownership of their education and career trajectories. Central to this professional attitude is the concept of personal responsibility, where students learn to take ownership of their actions and decisions, understanding the impact these choices have on their learning outcomes and interpersonal relationships. This fosters accountability and cultivates reliability and conscientiousness—traits essential in any professional environment. The approach highlights the significance of ethical conduct, teaching students values such as honesty, integrity, and respect. This foundation equips them to navigate moral dilemmas and make decisions aligned with ethical standards, which are crucial for maintaining professionalism in the workplace. The commitment to lifelong learning is also integral, instilling in students the

understanding that education is a continuous journey requiring them to seek new knowledge and adapt to changes in their fields. Through active engagement in their educational journeys, students develop a sense of ownership that empowers them to influence their experiences and set personal goals. This proactive approach extends to their careers, as they seek opportunities and take charge of their professional paths. Additionally, the emphasis on a strong work ethic teaches students the importance of diligence, persistence, and dedication in both academic and professional pursuits.

In summary, the “for the student” approach not only enriches academic learning but also cultivates vital life skills, preparing students for future challenges. By enhancing cognitive and metacognitive abilities, fostering self-thinking and innovation, and instilling a professional attitude, this comprehensive educational philosophy equips students with the essential traits and skills needed to thrive in their personal and professional lives. Ultimately, it prepares learners for a rapidly changing world where adaptability, creativity, and collaboration are key to success.

3.2 Teaching “of the student”

The “of the student” approach revolutionizes the educational landscape by centering students on their own learning journeys and highlighting the essential role of teachers in promoting student independence and active engagement. This model acknowledges that every student brings unique perspectives, experiences, and insights, which can be leveraged to enhance the educational environment. In contrast to traditional teaching methods that primarily focus on delivering content through lectures, this student-centered paradigm prioritizes each learner’s needs, abilities, and interests, resulting in a more personalized, engaging, and meaningful educational experience (Bremner et al., 2022).

A fundamental strategy within the “of the student” approach is **scaffolding**, which involves providing tailored support that gradually diminishes as students gain confidence and mastery (Meyer et al., n.d.). Skilled educators adapt their assistance to meet the individual needs of each student, effectively shifting the responsibility for learning from the teacher to the learner. This flexible approach allows for a customized learning experience, empowering students to take ownership of their educational paths. Another critical strategy is **self-monitoring**, which involves guiding students in setting specific learning goals and encouraging them to use both internal and external feedback to evaluate their progress (Meyer et al., n.d.). By reflecting on their learning strategies, students can assess their effectiveness and make necessary adjustments, which fosters a greater sense of accountability for their academic outcomes. Additionally, the approach emphasizes **modeling behavior**. Teachers encourage students to observe and emulate effective techniques for organizing information and developing study habits. This modeling helps students improve their memory and comprehension by providing practical examples to follow.

The development of **communication skills** focused on learning is also crucial. Educators create an environment that encourages students to articulate their thoughts and engage in discussions about their learning processes. This focus on communication not only helps students understand their own learning styles better but also enhances their ability to share insights with both peers and educators.

Furthermore, providing **constructive feedback** on assignments plays a significant role in reinforcing independent learning. Effective feedback aids students in identifying areas for improvement while boosting their confidence in working autonomously. This reflective practice encourages students to critically evaluate their work and further develop their skills.

The “of the student” approach fosters a sense of community by emphasizing **collaborative learning**. Students are encouraged to collaborate on projects, engage in discussions, and share insights, creating an interactive dynamic that facilitates knowledge sharing and builds supportive networks and relationships. This collaborative environment enhances motivation as students feel connected to their peers and invested in one another’s success. Through group work, they also develop essential social and interpersonal skills, such as communication, teamwork, conflict resolution, and empathy—qualities that are invaluable in both academic and professional contexts. The approach also champions **innovation and creativity** by recognizing students as active contributors to the educational process. Learners are encouraged to participate in curriculum design, propose topics of interest, and suggest innovative projects. This empowerment enables them to challenge traditional educational norms and fosters an atmosphere of creativity and critical thinking. When students feel safe to take risks in their learning, they are more likely to explore unconventional ideas and develop solutions to complex problems, ultimately enhancing their critical thinking skills.

The “of the student” approach also promotes **independent exploration**, granting students the autonomy to pursue their interests and curiosities. This independence nurtures intrinsic motivation, as students are more engaged when they can choose topics that resonate with them. They are encouraged to take charge of their research and learning processes by defining self-selected topics, formulating research questions, and pursuing independent projects. Moreover, it involves facilitating a learning environment where students feel empowered to express their thoughts, ask questions, and participate actively in their learning process. This self-directed learning not only helps students develop critical research skills and aligns their educational experiences with their career aspirations, preparing them for futures that reflect their values and interests, but is also supported by research indicating that when students are involved in pedagogical decision-making, their motivation and engagement levels increase significantly.

In summary, the “of the student” approach transforms the educational experience by prioritizing student agency, collaboration, innovation, and independent inquiry. It creates an environment where students actively participate in shaping their educational journeys rather than merely receiving information. This holistic approach equips learners with the essential skills necessary for academic and professional success, preparing them for a rapidly changing world that demands adaptability, creativity, and collaboration. Ultimately, the “of the student” philosophy envisions an education that is responsive, inclusive, and profoundly relevant to the lives and aspirations of students.

3.3 Teaching “by the student”

The “by the student” approach fundamentally reshapes the educational experience by actively involving students in their own learning processes. This method emphasizes student-led learning,

where learners are given significant responsibilities in the planning, design, and delivery of educational content. By positioning students as active educators, this approach fosters a sense of empowerment and ownership, encouraging them to take charge of their educational journeys. Rather than merely receiving information, students become knowledge sharers, leading discussions, presenting projects, and teaching their peers. This dynamic not only enriches the learning environment by incorporating diverse perspectives but also enhances collaborative learning among students.

Within this framework, **mentorship and leadership** are critical components (Danzig et al., 2007; Shinde and Bamber, 2023). Students have opportunities to guide and support their peers in grasping complex topics, which helps cultivate their leadership skills. This mentoring experience builds confidence and self-efficacy, both essential attributes of effective leadership. Furthermore, peer mentorship reinforces student’s understanding as they explain concepts to others, deepening their comprehension while developing essential interpersonal skills such as empathy, active listening, and effective communication. These interactions foster a sense of community within the classroom, which is vital for personal and academic growth.

Another cornerstone of the “by the student” approach is the **real-world application** of knowledge. This experiential learning bridges the gap between theoretical concepts and practical scenarios, making education more relevant and impactful. By engaging with real challenges, students enhance their critical thinking and problem-solving skills, learning to analyze situations, evaluate options, and make informed decisions. This hands-on experience not only prepares students for the complexities of professional environments but also boosts their employability, equipping them with a diverse portfolio of skills and experiences that are attractive to future employers.

Professionalism is a key element throughout the “by the student” approach. Students are held accountable not only for their own learning but also for the educational experiences of their peers. This shared responsibility fosters a sense of duty toward their educational community and encourages them to take their roles seriously. As they balance their responsibilities as educators or mentors, students develop effective time management skills. The emphasis on professionalism instills a commitment to producing quality work, highlighting the importance of high standards, constructive feedback, and continuous improvement. These experiences cultivate a robust work ethic that is essential in any professional setting.

In summary, the “by the student” teaching approach empowers students to take active roles in their education, enriching their learning experiences while cultivating vital leadership, mentorship, and professional skills. When integrated with the “for the student” and “of the student” approaches, it creates a comprehensive educational model that places students at the forefront of their learning. This trio of strategies fosters self-thinking, innovation, independent learning and a professional attitude, marking a significant shift from traditional teacher-centered education to a more dynamic, student-centered pedagogy. Ultimately, these approaches prepare learners not only for academic success but also for lifelong learning and fulfilment in their future careers.

4 Case studies and best practices

Margaret Mead’s assertion that students must be taught how to think, rather than what to think, underscores the shift from

teacher-centered to learner-centered pedagogy (Campbell, 2022; Mead, 1928). In this model, instructors act as guides, fostering student autonomy and collaboration. Today’s “digital native” students thrive in environments that integrate technology with experiential learning (Singh, 2021). The “for the student, of the student, by the student” approach promotes personalized, interactive education, enhancing flexibility and adaptability. This evolution in education emphasizes inclusivity and engagement, especially in scientific and digital settings, while also preparing students for real-world challenges.

4.1 Methodology

The study employs a student-centered model as implemented in the course “Molecular Basis of Cancer” course (MBC, ID: 76000123 Tsinghua SIGS) (MBC 2021–2024) for graduate science students. The primary objective is to examine the diverse impacts of the student-centered model on students’ academic and personal growth.

All students enrolled in the MBC course were included in the case study sample. This inclusive sampling method allows for the exploration of varying levels of engagement and personal growth resulting from the course structure, fostering an understanding of how different students experience and benefit from the model. To maintain

a focused investigation, only students actively participating in the MBC course are considered, excluding teachers and administrative staff from direct participation. Teachers acted solely as observers, which allows for unfettered access to the students’ experiences, learning dynamics, and peer interactions. This decision supports a clear focus on student-led initiatives and the resulting academic growth, without the influence of educator-driven assessments. Students participated in student-led presentations and peer-to-peer learning sessions, where they were assigned specific topics. The design of the course allowed for in-depth exploration of these topics while promoting the development of essential communication and analytical skills. Data was collected primarily through observational methods and the analysis of student-generated artifacts (e.g., presentations, peer assessments, and reflective writings) throughout the course. A comprehensive scoring sheet (Figure 1) was utilized to evaluate student performance during these presentations. The scoring sheet included criteria for both presentation skills and content organization, facilitating structured feedback and self-assessment among peers. This evaluation method further empowered students in their roles as assessors and result compilers, fostering an environment of collaborative learning.

Data analysis involved an iterative process of pattern development, where initial findings were continually revisited and refined

The molecular basis of cancer

Presenter Name: _____

Title: _____

Presentation Skills:

1. Clearly communicates the subject matter	1	2	3	4	5
2. Uses visuals appropriately	1	2	3	4	5
3. Validates students' questions and comments	1	2	3	4	5
4. Remains focused on topic	1	2	3	4	5
5. Displays enthusiasm	1	2	3	4	5

Content/Organization:

1. Clearly explains objectives of the lesson	1	2	3	4	5
2. Understanding of the material presented	1	2	3	4	5
3. Well organized and flows logically	1	2	3	4	5
4. Enough essential information to effectively evaluate	1	2	3	4	5
5. Clear and logical examples	1	2	3	4	5
Overall					

Scale: 5 = Excellent, 4=Good, 3=Satisfactory, 2=Needs Improvement, 1=Poor

Additional comments:

FIGURE 1 The figure illustrates the specific criteria used on the scoring sheet to assess student performance in the “Molecular Basis of Cancer” course.

throughout the study. As students completed their presentations and participated in peer assessments, scores were compiled and analyzed at the end of each semester. This approach allowed us to monitor progress and track changes over time, ensuring that we captured a comprehensive view of the evolving landscape of student learning. The quantitative data derived from the comprehensive scoring sheets served as a foundation for our analysis. Each semester, we evaluated the full range of results, taking care to include not only overall performance but also specific areas of strength and areas needing improvement in the presentation skills and content organization categories. This detailed evaluation enabled us to identify trends in student performance, which were essential for understanding the effectiveness of the student-centered approach. In addition to quantitative analysis, qualitative insights were gathered from reflections and feedback provided by students during peer assessments and class discussions. This qualitative data enriched our understanding of student experiences, revealing how their roles as educators and assessors influenced their learning processes. Patterns and themes emerged from this qualitative feedback, shedding light on students' perceptions of their growth in critical thinking, problem-solving, and communication skills.

4.2 Results

The “MBC” course offers a modern and innovative approach to student-centered education, which has been effectively implemented across diverse academic settings (Meza-Junco et al., 2006; Gorga, 1998; Glew, 1994; Gamboa Rodriguez et al., 2001; Howe, 2001). By emphasizing interactive and discussion-based learning, the course shifts away from traditional lecture-heavy formats. Instead, it focuses on active student participation through critical thinking, peer learning, and collaborative projects. This method is particularly effective in fields like oncology, where the rapid evolution of scientific knowledge demands a strong foundation and up-to-date

understanding of research advancements (Rangachari et al., 2022; Kang and Keinonen, 2018; Kulaksız et al., 2023). One of the course's defining features is the use of student-led presentations and peer-to-peer learning sessions. In these sessions, students are assigned specific topics, such as oncogenic signaling pathways, tumor suppressor gene functions, or metastasis mechanisms, and must present their findings to the class. This encourages students not only to delve deeper into the subject matter but also to refine their skills in conveying complex scientific concepts clearly and coherently. By adopting the role of educators, students improve their communication skills while enhancing their ability to analyze intricate topics. Additionally, the course promotes an interactive classroom environment where students ask questions, propose solutions, and debate differing viewpoints, a key component of the student-centered model (Wong, 2021).

This approach, which integrates discussion, independent inquiry, and collaborative research, is particularly valuable in developing a comprehensive understanding of cancer treatments, genetic research, and other cutting-edge topics. The course's relevance extends beyond academic learning, as students are encouraged to apply their theoretical knowledge to real-world challenges. For example, they explore novel molecular markers or therapeutic targets in oncology, fostering a bridge between classroom learning and clinical applications. Ultimately, this course prepares students to translate their scientific insights into diagnostic or therapeutic innovations, helping them contribute to significant breakthroughs in biomedical research. The positive observations of the student-centered model compared to traditional teaching are highlighted below (Figure 2).

4.2.1 More students opt for the course over time

The student-centered model significantly enhances student engagement, making courses more attractive and relevant (Tang, 2023). Unlike traditional methods that rely heavily on lectures, passive learning, and teacher-driven approaches, student-centered learning promotes **active participation, critical thinking, and greater ownership** of one's educational journey (Degago and Kaino, 2015). As students experience a

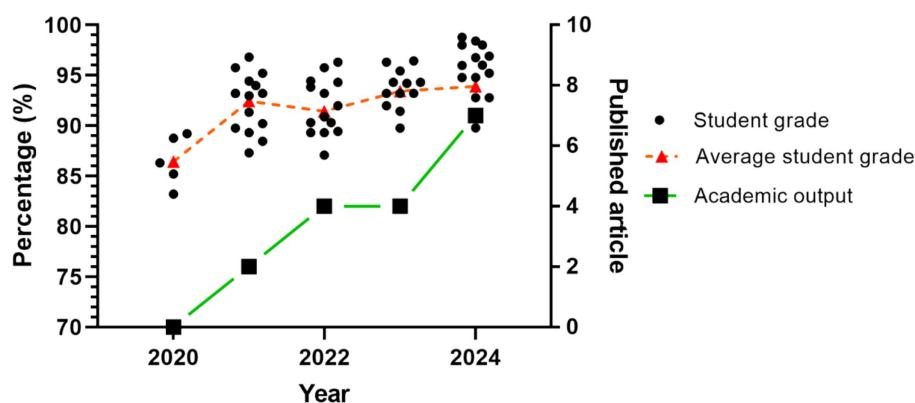


FIGURE 2

The graph illustrates the outcomes of implementing a student-centered teaching model in the “Molecular Basis of Cancer” course, which emphasizes teaching “for the student,” “of the student,” and “by the student.” This approach has led to several significant educational achievements. **Student engagement** has notably increased, as the model encourages active participation and ownership of learning. **Academic performance** has improved, with data showing a marked rise in student grades (Table 1), reflecting a deeper understanding of complex cancer biology topics. Additionally, the course has fostered greater **research output**, with students actively contributing to collaborative projects and discussions, resulting in an increase in published research articles (Table 2) and overall academic contributions. “Academic performance” refers to the measurable contributions and achievements of students as a result of the student-centered teaching model implemented in the course “Molecular Basis of Cancer”.

more interactive and personalized learning environment, they are more likely to provide positive feedback to peers, leading to increased enrolment over time. This approach not only draws more students but also fosters a dynamic academic community driven by collaboration and shared learning experiences (Table 1).

“Published research articles” refers to the formal academic papers that students have authored or co-authored as a result of their engagement in the “Molecular Basis of Cancer” course. These articles represent the synthesis of original research, findings, and insights that students have developed while participating in the student-centered teaching model, which emphasizes active learning and collaboration. The increase in published research articles signifies not only the students’ enhanced understanding of complex cancer biology topics but also their ability to contribute to the broader scientific community through dissemination of their work in academic journals (Table 2).

4.2.2 Multidisciplinary background students find the course interesting and adaptive

One of the key strengths of the student-centered model is its ability to engage students from a wide range of **multidisciplinary backgrounds** by making course content **adaptable** and interesting to their unique perspectives (Bremner et al., 2022; Shak, 2020). Students from various programs, such as data science, information technology, material science, environmental science, instrumentation, and pharmaceutical engineering, bring diverse expertise to the course. Their varied academic experiences lead to rich discussions and in-depth analysis, enabling them to approach topics from different angles. For instance, a student with an information technology background might analyze a problem using computational and quantitative methods, while a peer from an environmental science background might consider ethical and social implications. These diverse viewpoints foster opportunities for collaboration, critical thinking, and creative problem-solving that would be less accessible in traditional lecture formats. Moreover, the flexibility of the student-centered model allows for a dynamic integration of topics from different scientific areas and research fields (Kang and Keinonen, 2018). This flexibility encourages students to explore concepts through **discussion-based learning**, promoting deeper engagement with the material (Bremner et al., 2022; Muganga and Ssenkusu, 2019). As a result, students are empowered to connect their academic experiences with broader interdisciplinary topics, making their learning process more relevant and meaningful. This adaptability not only boosts their interest but also provides opportunities to explore interdisciplinary connections, enhancing their overall educational experience

4.2.3 Course platform promotes intense discussion with diverse implications of a topic

A defining feature of the student-centered model is its emphasis on collaborative learning and engaging in intense discussions (Motschnig-Pitrik and Holzinger, 2024; Bruffee, 1993). **Collaboration** is a cornerstone of this approach, breaking down traditional barriers of knowledge and expertise and empowering students to learn from one another (Bature and Atweh, 2019). This fosters an environment where students from diverse disciplines are encouraged to express their ideas, challenge assumptions, and engage in meaningful debates (Fallows and Steven, 2000; Holmes, 2013). These discussions not only deepen students’ understanding of course material but also expose them to a variety of perspectives and the broader implications of cancer-associated topics. The depth of discourse within this model enables students to connect

TABLE 1 Correlation between Grades and Percentage Scores for the Course “Molecular Basis of Cancer.” This table outlines the grading scale used in the course, detailing the relationship between letter grades and their corresponding percentage ranges.

Grade and percentage correlation	
Percentage	Grade
96–100	A+
91–95	A
86–90	A-
81–85	B+
76–80	B
71–75	B-
66–70	C+
61–65	C
Below 60	Fail

TABLE 2 This table showcases the academic publications resulting from student-led research conducted in the “Molecular Basis of Cancer” course. Students have co-authored original research articles that demonstrate their mastery of complex cancer biology concepts and their ability to contribute to the scientific community through peer-reviewed publications. This growing body of work reflects the success of the student-centered teaching model in fostering active learning, collaboration, and scholarly communication.

Academic year	Number of students	Published article
2020	5	NA
2021	15	Tan et al. (2021), Bhardwaj et al. (2021)
2022	14	Bhardwaj et al. (2022), Huang et al. (2022), Zhang et al. (2022), and Zhang et al. (2022)
2023	12	Zhang et al. (2024), Bhardwaj et al. (2023), Meng et al. (2024), and Guo et al. (2023)
2024	15 (Class in progress)	Reyad-Ul-Ferdous et al. (2024), Huang et al. (2024), Wolde et al. (2024), Tan et al. (2024a), Wang et al. (2024), Tan et al. (2024b), Huang et al. (2024), and Snijesh et al. (2024)

NA, not available.

theoretical concepts to real-world applications more effectively, enhancing their ability to analyze complex issues from multiple angles. As students engage in these discussions, they are naturally drawn to consider the practical implications of the topics they are exploring and how these ideas manifest in real-life contexts. This relevance ignites interest and further exploration, as students assess how abstract theories operate across various fields. For instance, a group of students successfully contributed and published an article in an international peer-reviewed journal on how

artificial intelligence and machine learning—a subcategory of data science—can be applied to predict endometrial cancer (Bhardwaj et al., 2022). This example illustrates how multidisciplinary collaboration enables students to pool their diverse knowledge and experiences, resulting in innovative, multidimensional approaches to complex problems.

4.2.4 Senior researchers also voluntarily opt for the course

The interactive and flexible nature of student-centered courses frequently attracts senior researchers, such as postdoctoral fellows, who are seeking **advanced learning and intellectual stimulation**. These individuals, driven by a passion for continuous growth, find the exploratory nature of student-centered learning to be a perfect fit. By engaging in courses that emphasize collaborative inquiry and critical thinking, senior researchers not only expand their knowledge but also contribute their valuable experiences to discussions that challenge conventional ideas. This dynamic interaction enriches the learning environment for all participants, fostering a culture of mutual growth and highlighting the importance of lifelong learning in academia. Moreover, senior researchers often report that the student-centered approach fosters creative thinking and exploration, enabling them to identify gaps or emerging opportunities in their respective fields. Immersing themselves in such a collaborative and intellectually stimulating setting allows them to rethink their perspectives, leading to innovative insights. Upon completing the course, many senior researchers express a renewed commitment to contribute to their fields, often through publications. This renewed motivation may manifest in various ways, such as synthesizing key findings into literature reviews or conducting original research inspired by the collaborative brainstorming sessions with younger peers. Ultimately, the inclusion of senior researchers enhances the academic community, sparking creativity, collaboration, and intellectual discovery.

4.2.5 Positively impacts the overall grades of the students and class

Research indicates that the active participation fostered by the student-centered model leads to improved academic performance (Al-Shehri and Alaudan, 2024). As students engage more deeply with the material, they develop a better understanding of key concepts, which translates to higher grades and overall success in their coursework. The continuous feedback mechanisms inherent in this model help students identify areas for improvement and clarify misconceptions in real time. This responsive approach not only boosts individual performance but also raises the academic standards of the entire class, creating a more motivated and high-achieving learning community. The transition to a student-centered model in the “Molecular Basis of Cancer” course demonstrates marked improvements in student performance compared to the more traditional teacher-centered approach used in the year 2020. By promoting active engagement, collaboration, ownership of learning, immediate feedback, real-world applications, and critical thinking, students are better equipped to understand the complexities of the subject matter. As a result, these factors culminate in higher grades and deeper mastery of concepts. The evidence from this course exemplifies how student-centered learning environments can fundamentally transform educational outcomes, reinforcing the importance of adopting innovative teaching methodologies in the field of higher education. This shift not only enhances the **academic**

performance (Figure 2) of students but also prepares them to become informed and capable professionals in the future.

4.2.6 Course topic-associated outcomes of manuscripts

Research consistently shows that active participation encouraged by the student-centered model significantly enhances academic performance (Gijbels et al., 2008). By deeply engaging with the material, students gain a stronger grasp of key concepts, leading to higher grades and overall success in their studies. The continuous feedback mechanisms embedded in this approach allow students to quickly identify areas for improvement and resolve misunderstandings, fostering immediate growth. This adaptability not only improves individual performance but also elevates the academic standards for the entire class, cultivating a motivated, high-achieving learning community. In the “Molecular Basis of Cancer” course, transitioning from a teacher-centered model used in 2020 to a student-centered approach has resulted in notable improvements in student performance (Figure 2, Table 2). Through active engagement, collaboration, personal ownership of learning, real-time feedback, and the practical application of concepts, students have developed a deeper understanding of the complexities of cancer biology. These factors contribute to higher grades and a more profound mastery of the subject (Figure 2). This evidence highlights the **transformative power** of student-centered learning environments and underscores the value of adopting innovative teaching methods in higher education. Not only do these approaches enhance academic outcomes, but they also prepare students to become informed, capable professionals ready to contribute meaningfully to their fields.

4.2.7 Student’s feedback-based improvements integration

In a student-centered learning environment, student-led feedback mechanisms act as a powerful driver for **continuous improvement** in both teaching and learning (Zhang et al., 2021). This approach encourages students to actively reflect on their learning experiences and offer insights on course content, teaching methods, and classroom dynamics, promoting a culture of open communication and mutual accountability (Prosser and Trigwell, 1990). Through tools like anonymous surveys, group discussions, and reflective journals, students provide valuable feedback that enables educators to make real-time adjustments, tailoring the course to meet diverse learning needs. When students witness their feedback leading to meaningful changes, they feel a stronger sense of ownership over their education, enhancing their engagement. This collaborative feedback process also hones critical thinking, communication, and self-reflection skills, as students learn to provide constructive input. Ultimately, the student-centered model makes the course more engaging, adaptable, and research-oriented, improving academic performance and attracting a broader range of learners, including senior researchers.

5 Discussion

5.1 Impact on student outcomes

The “for the student, of the student, and by the student” approach fundamentally reshapes the educational experience by placing **student**

agency at the forefront, significantly enhancing students' **holistic development** and preparing them for future success. This model aligns with the principles of Self-Determination Theory (SDT), as proposed by Deci and Ryan, which underscores the significance of **intrinsic motivation** and the fulfillment of three innate psychological needs: autonomy, competence, and relatedness (Ryan and Deci, 2020). By empowering learners to take an active role in their educational journeys, we foster an environment that promotes autonomy, nurtures competence, and encourages relatedness, thereby igniting intrinsic motivation. This, in turn, leads to increased involvement, increased effort, and ultimately, enhanced academic achievement, as learners become more invested in their own learning and development. Central to this approach is the development of **critical thinking** and **problem-solving skills**; students are encouraged to analyze information, engage in creative project-based learning, and develop innovative solutions to real-world challenges (Kahl and Venette, 2010). Additionally, the focus on **collaborative learning** fosters essential **social and emotional skills**, such as communication, teamwork, and leadership, while cultivating a strong sense of community among peers (Dogani, 2023; Trigwell and Prosser, 1991). Moreover, the approach aligns with the foundational principles of **Constructivist Learning** Theory, as proposed by Jean Piaget and Lev Vygotsky (Shah, 2019; Bada and Olusegun, 2015). According to, learning is a constructive process where individuals actively construct meaning from experiences, building upon existing knowledge and understanding. This process is characterized by adaptation, assimilation, and accommodation, reflecting the cyclical nature of learning. Similarly, posited that social interaction plays a pivotal role in constructivist learning, emphasizing the importance of collaborative dialog, scaffolding, and peer-to-peer learning (Vygotsky, 2012). Our “for the student, of the student, and by the student” approach embodies the core constructivist tenets: student agency, social interaction, and knowledge construction. By fostering a learning environment where students actively engage in knowledge-building and problem-solving, we support the notion that learning is a dynamic, self-regulated process where individuals construct their own understanding and meaning. This constructivist foundation underpins our student-centered strategies, emphasizing the value of active learning, collaborative environments, and student-led discovery.

Accountability is another vital aspect of this model, as students learn to take responsibility for their learning and the learning of others, which prepares them for **lifelong learning** (Martin-Alguacil et al., 2024; Hodges, 2020). By nurturing **self-directed education**, students develop resilience and adaptability—traits crucial for thriving in a rapidly changing world. Furthermore, this approach enhances **employability** by equipping students with diverse skills like critical thinking, effective communication, and **digital literacy** that align closely with employer expectations, making graduates more competitive in the job market (The Future of Education, 2022). Opportunities for real-world application through internships and practical projects deepen their understanding of industry practices, further boosting their readiness for professional environments.

Moreover, the emphasis on **personal relevance** in learning leads to greater student satisfaction and engagement, as learners can connect their education to their own interests and real-life experiences (Wright, 2011). This active involvement fosters a sense of **belonging** and promotes overall well-being, positively affecting students' mental health. Ultimately, by adopting the “for the student, of the student, and

by the student” philosophy, educational institutions not only enhance **academic achievement** but also cultivate vital life skills, empowering students to thrive both academically and personally in their future endeavors (Bara and Xhomara, 2020).

5.2 Teacher's role in a student-centered approach

In a student-centered approach, the role of the teacher undergoes a significant transformation from traditional instruction to a more facilitative and supportive role (Woods and Copur-Gencturk, 2024; Wright, 2011). This shift is pivotal in creating an engaging and empowering learning environment that prioritizes students' needs, interests, and abilities.

In traditional educational models, teachers often act as the primary source of knowledge, delivering content through lectures and direct instruction. However, in a student-centered approach, teachers transition to **facilitators of learning** (Dunbar and Yadav, 2022). This involves creating an environment where students take the lead in their education, encouraging them to explore, inquire, and collaborate. A study done by Al-Balushi et al. (2020) examine teachers' and their supervisors' perceptions of student-centered classrooms, indicating that the learning process is significantly influenced by the educators' attitudes toward student-centered strategies (Al-Balushi et al., 2020). Teachers guide discussions, pose thought-provoking questions, and provide resources rather than solely imparting information. They observe students' interactions and progress, offering targeted support as needed. This shift encourages students to develop critical thinking, problem-solving skills, and a sense of ownership over their learning. By stepping back, teachers allow students to engage more deeply with the content, fostering a sense of autonomy and responsibility (Katawazai, 2021).

To effectively implement a student-centered approach, teachers must engage in ongoing **professional development** and training. This training equips educators with the necessary skills to adapt their teaching strategies to better support student learning (Darling-Hammond et al., 2017). Professional development programs should focus on pedagogical techniques that promote active learning, such as collaborative teaching methods, project-based learning, and formative assessment strategies. Teachers need training in differentiating instruction to meet diverse learning needs and in using technology to enhance student engagement. Additionally, educators must develop skills in fostering a supportive classroom culture that values student voice and choice. For instance, the work done by Rich (2021) investigates teacher agency when using mathematical instructional programs, indicating that empowering teachers alongside students enhances the implementation of student-centered learning approaches (Rich, 2021). This dual empowerment can lead to a transformative classroom experience that benefits both educators and learners. Continuous professional development not only enhances teachers' competencies but also contributes to their confidence in adopting new methodologies, ultimately benefiting student outcomes (Darling-Hammond et al., 2017; Germuth, 2018; Lopes and Cunha, 2017).

Collaboration and support among educators are essential for successfully implementing a student-centered approach. Teachers benefit from sharing experiences, strategies, and resources within their educational communities. Collaborative practices, such as

co-teaching, peer observation, and professional learning communities, allow teachers to learn from one another and refine their practices (Katal et al., 2022; Antinluoma et al., 2021; Musanti and Pence, 2010). This supportive network encourages the sharing of best practices and innovative ideas, creating a culture of continuous improvement. Additionally, schools and districts should provide structures that facilitate collaboration, such as regular planning time, mentorship programs, and access to professional development resources. By fostering a collaborative environment, educators can collectively address challenges, share successes, and ultimately enhance the overall effectiveness of student-centered teaching strategies.

In summary, the role of the teacher in a student-centered approach is multifaceted and transformative (Woods and Copur-Gencturk, 2024). By shifting from traditional instruction to facilitative roles, engaging in professional development, and collaborating within educational communities, teachers can effectively support and empower students in their learning journeys (Brooks et al., 2021). This holistic approach not only enriches the educational experience for students but also fosters a dynamic and adaptive teaching environment that promotes lifelong learning.

5.3 Policy implications and recommendations

To effectively implement student-centered education, several key policy changes and recommendations are necessary to create an engaging and empowering learning environment (Young et al., 2024). First, **curriculum flexibility** is essential, enabling educators to tailor learning experiences to diverse student needs, interests, and learning paces (Jonker et al., 2020). By integrating project-based learning, interdisciplinary studies, and experiential opportunities, schools can foster deeper student engagement with content that resonates with their interests. This approach encourages more meaningful learning and better student outcomes.

A critical area for policy reform is the **assessment system** (Thurlow, n.d.; Masters, 2013). Traditional standardized testing should be reconsidered in favor of **formative and authentic assessments** that prioritize critical thinking, creativity, and collaboration. These assessments, such as portfolios, presentations, and peer evaluations, offer a more comprehensive view of student learning, moving beyond rote memorization to capture a fuller picture of progress and skills.

In addition to curriculum and assessment changes, **professional development and training** for teachers are crucial to successfully adopting student-centered approaches (Germuth, 2018). Schools should allocate resources for continuous professional development programs that help teachers master new pedagogies focused on collaboration, differentiation, and the effective integration of technology in the classroom. This will ensure that teachers are well-prepared to address the diverse needs of their students. Furthermore, **equitable resource allocation** is vital for student success, particularly in underfunded or underserved communities (Rana, 2024). Policies must ensure that all students have access to necessary technology, learning materials, and support services, providing a level playing field for every learner.

Additionally, **parental and community engagement** plays an essential role in student-centered education (Đurišić and Bunijevac, 2017; Kelty and Wakabayashi, 2020). Schools should create policies

that actively involve parents and community members in educational initiatives, fostering partnerships that help bridge the gap between home and school. This kind of engagement enhances the relevance of education and strengthens the support network available to students. For **school administrators and policymakers**, it is critical to establish a culture that values **student voice and agency**. Administrators should promote environments where students participate in decision-making processes and contribute to the design of their educational experiences. Facilitating **collaborative teaching models**, where educators work across disciplines and share best practices, can also enrich the overall learning experience (Brown et al., 2021; Zamiri and Esmaeili, 2024).

To explore and refine student-centered practices, **pilot programs** should be implemented. These programs can serve as test cases for innovative approaches, providing valuable insights and models for broader adoption across different educational contexts (Ammar et al., 2024). Continuous **monitoring and evaluation** mechanisms must be established to collect data on student engagement, achievement, and well-being, ensuring that policies and practices are effectively supporting students and allowing for adjustments as needed (Cotton, 1988).

Looking forward, **longitudinal studies** are necessary to assess the long-term impact of student-centered approaches on academic success, personal development, and career readiness (ERIC-ED581111, 2018). Research should also examine how these practices are implemented in diverse educational settings, including urban, rural, and low-income schools, to identify strategies that can support all types of learners. The role of **technology** in enhancing student-centered learning warrants further exploration as well. By investigating how digital tools can promote engagement, collaboration, and personalized learning, educators can better integrate technology into their teaching practices (Kerimbayev et al., 2023).

Lastly, understanding **student perspectives** is critical. Engaging students in research about their learning experiences provides invaluable feedback that can inform instructional design and shape educational policies, ensuring that education remains relevant and responsive to their needs. This holistic approach not only improves academic performance but also fosters essential life skills, equips students for the workforce, and promotes a mind-set of lifelong learning, ultimately preparing them for success in an increasingly complex and dynamic world.

6 Limitation

While our study clearly outlines its **intent and objectives**, it is essential to acknowledge several **limitations** that may affect the **robustness and generalizability** of the findings. Firstly, the effectiveness of the **student-centered approach** can be heavily influenced by the characteristics of the **population studied**; a limited or homogenous **sample** may restrict the applicability of the findings to a wider educational context. Secondly, evaluating outcomes shortly after implementing the student-centered approach may not fully capture its **long-term effects** on **critical thinking, problem-solving skills, and professional attitudes**. The study also relies on specific **measurement tools** to assess **engagement, critical thinking, and independence**, which may not fully encompass these complex constructs. Additionally,

variations in **contextual factors** such as classroom environments, institutional support, and available teaching resources can significantly impact the effectiveness of student-centered methods. It is crucial to consider **instructor variability**, as differences in performance and teaching styles can influence student engagement and learning outcomes. Furthermore, some students may initially resist the transition to a student-centered approach, affecting engagement levels and the overall evaluation of the teaching strategy's effectiveness. Qualitative data gathered from student perspectives may be subject to **bias**, limiting the validity of the findings. Moreover, the study's focus on a specific **course** may not necessarily be applicable to other disciplines due to variations in educational contexts and skill requirements. Inconsistencies in the effective **implementation** of student-centered approaches among instructors may also impact the accuracy of the findings. Finally, **institutional constraints** could limit the full execution of student-centered strategies, affecting the conclusions regarding their overall effectiveness. In conclusion, while the study presents a strong case for student-centered learning, recognizing these limitations is crucial for accurately interpreting the results and making informed recommendations for future **pedagogical practices**.

7 Conclusion

In conclusion, the implementation of teaching approaches that encompass “for the student, of the student, and by the student” within educational curricula holds significant promise for transforming student learning experiences. The comprehensive research objectives outlined reveal a clear intent to assess various facets of student development, including engagement, critical thinking, independence, and professional attitudes. By systematically assessing these variables and comparing them to traditional teacher-centered methods, the study aims to provide robust evidence supporting the effectiveness of student-centered teaching strategies.

Initial assessments of student engagement are expected to demonstrate higher levels of participation and enthusiasm among students exposed to these innovative approaches, fostering a more vibrant learning environment. Evaluating critical thinking skills will highlight the potential for deeper cognitive development, as students navigate complex problems and engage in meaningful discourse. Additionally, the investigation into independent learning behaviors is anticipated to reveal a marked increase in self-directedness, with students taking initiative in their learning journeys (Meyer et al., n.d.). The analysis of professional attitudes will provide insights into the ethical and communicative competencies developed through this pedagogical shift, equipping students with skills crucial for their future careers. Qualitative data gathered from student perspectives will enrich our understanding of the experiential nuances and challenges inherent in these teaching approaches, paving the way for continual refinement and enhancement. Furthermore, a comparison of academic performance will substantiate claims of improved learning outcomes, showcasing enhanced grades and knowledge retention among students engaged in student-centered model.

Moreover, our initial implementation of the student-centered model in the “Molecular Basis of Cancer” course has yielded positive

outcomes, and we are now expanding this approach to two additional courses, “Emerging Concepts of Cancer Research” and “Current Topics in Cancer Biology.” This larger-scale adoption will provide a unique opportunity to further evaluate the effectiveness of this teaching approach and its impact on student learning outcomes. By replicating and refining this approach across multiple courses, we aim to create a more comprehensive understanding of its strengths and limitations, ultimately informing best practices in teaching and learning.

Ultimately, this study has the potential to inform and inspire a significant shift in educational practice. By identifying best practices and offering evidence-based, actionable recommendations, we contribute to the ongoing discourse on effective teaching methodologies. We encourage future researchers to delve into the long-term impacts of such transformative practices on student outcomes and professional success, thereby laying the groundwork for a new generation of learners who are not only equipped with the necessary skills and attitudes for success in a rapidly evolving world but are also prepared to navigate and shape the future of their respective fields.

Author contributions

VB: Formal analysis, Methodology, Writing – original draft, Writing – review & editing. SZ: Writing – review & editing. YT: Writing – review & editing. VP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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