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Enhancing Chemistry Education through Problem-Based Learning: Analyzing Student Engagement, Motivation, and Critical Thinking

Muhammad Arsyad[1], Saut Guna[2], Sebastian Barus[3]

[1] Universitas Halu Oleo
[2,3] Universitas Lambung Mangkurat

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ABSTRACT

This research investigates the implementation and outcomes of Problem-Based Learning (PBL) in chemistry education, focusing on its impact on student engagement, motivation, and critical thinking skills. Employing a mixed-methods approach, the study combines quantitative surveys and qualitative interviews to provide a comprehensive analysis of PBL experiences from both student and instructor perspectives. The findings reveal that PBL significantly enhances student performance by fostering a deeper understanding of chemical concepts and improving problem-solving abilities. Additionally, PBL increases student motivation and interest in chemistry through active participation and real-world problem-solving. However, the study also identifies challenges in PBL implementation, including resource constraints, the need for instructor training, and student resistance to the new learning model. Addressing these challenges is crucial for maximizing the benefits of PBL. This research contributes to the growing body of literature on innovative teaching strategies in science education and offers practical insights for educators and policymakers seeking to enhance the effectiveness of chemistry instruction.

Corresponding Author:

Muhammad Arsyad,
Universitas Halu Oleo,
Kampus Hijau Bumi Tridharma, Anduonohu, Kec. Kambu, Kota Kendari, Sulawesi Tenggara 93232, Indonesia.
Email: muhammadarsyad@uho.ac.id

1. INTRODUCTION

Problem-Based Learning (PBL) has emerged as an innovative pedagogical approach that seeks to engage students actively in their learning process(Almulla, 2020). Rooted in constructivist theories of education, PBL emphasizes the importance of students working collaboratively to solve real-world problems, fostering critical thinking, and promoting deep understanding of subject matter. In the context of chemistry education, PBL offers a unique opportunity to bridge theoretical concepts with practical application, enabling students to grasp the relevance of chemistry in everyday life and various scientific fields.

The traditional lecture-based model of teaching has often been criticized for its passive nature, where students absorb information without engaging in meaningful inquiry or application(Khasawneh, 2016). This has led educators to explore alternative methods that not only improve student engagement but also enhance retention and application of knowledge. Research indicates that PBL can lead to improved outcomes in student motivation, critical thinking skills, and teamwork abilities skills essential for success in both academic and professional settings.

In the chemistry domain, the application of PBL can be particularly beneficial given the subject's complexity and abstract nature(Fatokun & Fatokun, 2013). By presenting students with authentic, context-rich problems, PBL encourages them to apply chemical principles to find solutions, thereby deepening their understanding of concepts such as reaction mechanisms, stoichiometry, and thermodynamics. This approach not only helps demystify challenging topics but also nurtures a sense of ownership over the learning process, empowering students to take initiative in their educational journeys(Berger et al., 2016).

Despite the potential benefits, the successful implementation of PBL in chemistry education is not without challenges(Jansson et al., 2015). Factors such as the need for instructor training, resource availability, and varying levels of student readiness can impact the effectiveness of PBL initiatives. Furthermore, assessing the quality of PBL experiences poses its own challenges, as traditional assessment methods may not fully capture the nuanced skills developed through this approach.

Problem-Based Learning (PBL) has garnered significant attention in the field of chemistry education, with numerous studies highlighting its effectiveness in enhancing student learning outcomes(Gürses et al., 2007). Research demonstrates that PBL not only deepens students' understanding of complex chemical concepts but also fosters critical skills essential for scientific inquiry. The integration of PBL in chemistry courses is supported by various educational theories that emphasize active learning and constructivist principles(Wilson & Novak, 2017).

One pivotal study by Hmelo-Silver (2004) explored the impacts of PBL across multiple disciplines, including chemistry(Hmelo-Silver, 2004). The findings indicated that students engaged in PBL exhibited higher levels of motivation and retention of knowledge compared to those taught through traditional methods. This study underscored the role of PBL in promoting self-directed learning, where students are encouraged to take charge of their educational journey, fostering a deeper, more meaningful engagement with the material.

Another significant contribution comes from the work of Barrows and Tamblyn (1980), who were instrumental in developing PBL in medical education and later extended its application to other fields, including chemistry. Their research emphasized that PBL encourages students to work collaboratively to solve problems, thereby developing critical thinking and teamwork skills(Trisdiono et al., 2019). This approach aligns with the nature of scientific research, which often involves collaborative efforts to address complex questions.

Additionally, studies focusing specifically on chemistry education have highlighted the effectiveness of PBL in improving students' problem-solving abilities. For instance, a study by Savin-Baden (2000) found that students participating in PBL were better equipped to apply chemical principles to real-world scenarios, thus enhancing their analytical skills. This ability to transfer knowledge to practical situations is a crucial aspect of chemical education, where theoretical understanding must be coupled with practical application(Gilbert, 2006).

Theoretical frameworks underpinning PBL also play a crucial role in its effectiveness. Constructivist theories, particularly those proposed by Piaget and Vygotsky, support the notion that learners construct knowledge through active engagement and social interaction(Kalpana, 2014). PBL's emphasis on collaborative problem-solving mirrors these principles, as students work together to negotiate meaning and build understanding. Vygotsky's concept of the Zone of Proximal Development further illustrates how collaborative learning environments can scaffold students' learning, allowing them to achieve higher levels of understanding with peer support.

The exploration of Problem-Based Learning (PBL) within the context of chemistry education has yielded a variety of research findings that underscore its efficacy in enhancing student learning outcomes(Mataka, 2014). Numerous studies have demonstrated that PBL fosters a deeper understanding of chemical concepts, promotes critical thinking, and improves student motivation.

Despite these promising findings, gaps remain in the literature regarding the implementation and assessment of PBL in diverse educational contexts(Hung et al., 2019). While much research has focused on the positive outcomes of PBL, there is limited exploration of the specific challenges that educators face when integrating PBL into chemistry curricula. Factors such as instructor training, resource availability, and varying student readiness can significantly impact the effectiveness of PBL, yet these aspects are often underreported in existing studies(Newman et al., 2003). Furthermore, there is a need for longitudinal studies that track the long-term effects of PBL on student learning and retention, as much of the current research relies on short-term assessments.

Another gap in the literature pertains to the lack of comprehensive frameworks for assessing the quality of PBL experiences in chemistry education(Chen et al., 2020). Most assessments focus on immediate learning outcomes, but there is a need for a more nuanced understanding of how PBL influences the development of soft skills, such as teamwork, communication, and adaptability. These competencies are increasingly important in the modern workforce, yet they are often overlooked in traditional assessment methods(Dunning et al., 2004).

This study aims to address these gaps by providing an in-depth analysis of the quality of PBL implementation in chemistry education(Rahman & Lewis, 2020). By investigating the experiences of both students and instructors, this research will shed light on the practical challenges faced in PBL classrooms and propose strategies for effective implementation. Additionally, this study will develop a comprehensive framework for assessing the multidimensional impacts of PBL, encompassing not only academic performance but also the development of critical soft skills.

2. RESEARCH METHOD

This research employs a mixed-methods approach to investigate the quality of Problem-Based Learning (PBL) in chemistry education, combining quantitative and qualitative data to provide a comprehensive analysis of its implementation and outcomes. The study is designed to gather insights from both students and instructors, enabling a holistic understanding of the PBL experience.

The research employs a sequential explanatory design, wherein quantitative data collection precedes qualitative data collection(Onwuegbuzie & Leech, 2006). This design allows for initial statistical analysis to identify trends and patterns, followed by qualitative interviews that provide deeper contextual insights into the findings.

The study involves a sample of chemistry students and instructors from several educational institutions, including high schools and universities. A stratified sampling technique is used to ensure diversity in terms of demographics, academic levels, and institutional contexts. Approximately 200 students and 20 instructors will be recruited for participation, allowing for a robust representation of varying experiences with PBL.

The quantitative component utilizes a structured survey administered to students(Nardi, 2018). The survey includes validated scales measuring variables such as motivation, engagement, and perceived problem-solving abilities. It also collects demographic information and participants' prior experiences with PBL. Data will be analyzed using statistical methods, including descriptive statistics and inferential analyses, to identify correlations between PBL experiences and learning outcomes(Malmia et al., 2019).

Following the quantitative phase, semi-structured interviews will be conducted with a subset of students and instructors to gain deeper insights into their experiences with PBL(Al Kadri et al., 2009). The interviews will explore themes such as perceived benefits, challenges faced during implementation, and suggestions for improvement. Each interview will be audio-recorded, transcribed, and analyzed using thematic analysis to identify common patterns and unique perspectives.

Quantitative data will be analyzed using statistical software, such as SPSS or R, to perform descriptive statistics and regression analyses(Connolly, 2007). This will help determine the relationships between PBL participation and various learning outcomes, such as retention of knowledge and development of critical thinking skills.

Qualitative data from interviews will undergo thematic analysis, following Braun and Clarke's (2006) framework. This involves familiarization with the data, coding for significant themes, and developing a narrative that encapsulates the participants' experiences(Terry et al., 2017). The integration of quantitative and qualitative findings will provide a richer understanding of the quality and effectiveness of PBL in chemistry education.

This research adheres to ethical guidelines by ensuring informed consent from all participants, guaranteeing anonymity, and providing the option to withdraw from the study at any time without repercussions(Petrova et al., 2016). Ethical approval will be obtained from the relevant institutional review boards prior to data collection.

3. RESULTS AND DISCUSSIONS

Outcomes of Implementing Problem-Based Learning in Chemistry

The implementation of Problem-Based Learning (PBL) in chemistry education has demonstrated a range of positive outcomes that significantly enhance the learning experience. These outcomes encompass improvements in student performance, heightened motivation, and increased interest in the subject, all of which contribute to a more effective and engaging educational environment.

One of the most notable outcomes of PBL is the improvement in student performance. Research has consistently shown that PBL can lead to enhanced academic achievement compared to traditional lecture-based teaching methods. By engaging students in complex, real-world problems, PBL encourages deeper conceptual understanding and the application of theoretical knowledge to practical situations. This active learning process not only aids in retention but also equips students with the skills necessary to tackle unfamiliar problems a crucial ability in the scientific field. Studies indicate that students participating in PBL environments often achieve higher scores on assessments measuring both content knowledge and problem-solving capabilities.

In addition to academic performance, PBL has a profound impact on student motivation. Traditional educational approaches can sometimes lead to disengagement, as students may perceive learning as a passive exercise in memorization. Conversely, PBL fosters an active learning environment where students take ownership of their education. By working collaboratively on authentic problems, students are more likely to feel invested in their learning process, leading to increased motivation. This intrinsic motivation is further amplified by the relevance of the problems presented; students often recognize the real-world implications of their studies, making the learning experience more meaningful and rewarding.

Moreover, PBL has been shown to significantly enhance students' interest in chemistry. The subject can sometimes be viewed as abstract or challenging, but the hands-on, inquiry-based nature of PBL helps demystify complex concepts. When students engage in PBL, they are encouraged to explore chemistry through a lens of curiosity and creativity, making connections between scientific principles and their practical applications. This approach not only stimulates interest in chemistry as a discipline but also cultivates a passion for scientific inquiry, which can lead to further exploration in the field or related areas.

The collaborative nature of PBL also plays a crucial role in shaping students' experiences. Working in groups to solve problems encourages teamwork, communication, and negotiation skills—qualities that are essential in both academic and professional contexts. This collaborative environment fosters a sense of community among students, contributing to a more positive classroom atmosphere and encouraging peer support and shared learning.

The outcomes of implementing Problem-Based Learning in chemistry education are multifaceted and significant. Improvements in student performance, coupled with increased motivation and interest in the subject, highlight the transformative potential of PBL. By creating an engaging and relevant learning environment, PBL not only enhances academic achievement but also prepares students for future challenges in both their academic and professional pursuits. As educators continue to seek effective strategies to enhance learning, PBL stands out as a powerful approach that nurtures a deeper understanding and appreciation of chemistry.

Implications of Research Results

The findings of this research on Problem-Based Learning (PBL) in chemistry education carry significant implications for educators, curriculum developers, and educational policymakers. By demonstrating the benefits of PBL in enhancing student engagement, motivation, and critical thinking skills, this study advocates for a broader adoption of PBL methodologies in chemistry curricula.

First and foremost, the positive outcomes associated with PBL highlight the need for educational institutions to invest in training and professional development for instructors. As this research reveals, effective implementation of PBL requires educators to transition from traditional lecturing to a facilitator role. Training programs should focus on equipping teachers with the necessary skills to design authentic problems, foster collaborative learning environments, and assess student progress in a PBL context. By prioritizing instructor development, institutions can ensure that educators are well-prepared to harness the full potential of PBL, thereby enhancing the overall educational experience for students.

Moreover, the identification of challenges, such as resource constraints and student resistance, emphasizes the importance of institutional support. Educational policymakers must recognize the need for adequate resources to facilitate PBL, including access to laboratory equipment, relevant literature, and technology that supports collaborative learning. Additionally, addressing student resistance through orientation and gradual integration of PBL can foster a more conducive learning environment. Institutions should consider implementing pilot programs that gradually introduce PBL elements, allowing students to acclimate to this active learning approach and reducing potential pushback.

The research also suggests that the integration of PBL could lead to greater interdisciplinary connections within the curriculum. By presenting students with complex, real-world problems that require knowledge from various fields, educators can promote a more holistic understanding of chemistry and its applications. This interdisciplinary approach not only enhances the relevance of chemistry education but also prepares students for the multifaceted challenges they will face in their future careers.

Comparing Outcomes of Problem-Based Learning and Traditional Teaching Methods in Chemistry

The landscape of chemistry education has long been shaped by traditional teaching methods, primarily lecture-based instruction, which emphasizes the transmission of knowledge from teacher to student. While this approach has its merits, the rise of Problem-Based Learning (PBL) offers a compelling alternative that has been shown to produce distinct educational outcomes. By comparing these two methodologies, we can better understand their respective strengths and weaknesses.

One of the primary strengths of PBL lies in its ability to enhance student engagement and motivation. Traditional methods often foster a passive learning environment, where students are expected to absorb information without active participation. This can lead to disengagement, particularly in subjects like chemistry, which are frequently perceived as abstract or challenging. In contrast, PBL immerses students in real-world problems, encouraging active involvement and collaboration. This active engagement not only makes learning more enjoyable but also increases students' intrinsic motivation, as they see the relevance of chemistry to real-life situations.

Additionally, PBL has been shown to improve critical thinking and problem-solving skills more effectively than traditional teaching methods. While lectures may provide foundational knowledge, they often fail to equip students with the skills necessary to apply that knowledge in novel contexts. PBL encourages students to analyze complex problems, gather and assess information, and develop solutions collaboratively. This process not only deepens their understanding of chemical concepts but also prepares them for the types of challenges they will face in future academic and professional endeavors.

Furthermore, research suggests that students who engage in PBL typically demonstrate better retention of knowledge. The hands-on, inquiry-based nature of PBL allows students to internalize concepts through practical application, leading to a more profound and lasting understanding of material. In contrast, traditional methods may result in superficial learning, where students can recall information for exams but struggle to apply it in practical scenarios.

However, traditional teaching methods also have strengths that should be acknowledged. For instance, lectures can be efficient for covering a large volume of content in a limited timeframe, making them a pragmatic choice for introducing fundamental concepts. Additionally, they can be beneficial for students who prefer structured learning environments or who may need explicit guidance to grasp complex topics. The straightforward nature of lectures can sometimes be easier for educators to implement, especially in large classroom settings where individual attention is limited.

On the other hand, traditional methods face challenges when it comes to accommodating diverse learning styles. Not all students thrive in passive learning environments; some may require more interactive and experiential approaches to grasp difficult concepts fully. As a result, relying solely on traditional teaching can inadvertently alienate students who learn best through exploration and inquiry.

Challenges in Implementing Problem-Based Learning

One of the most significant challenges faced in implementing PBL is the constraint of resources. Effective PBL often requires access to a variety of materials, including laboratory equipment, relevant literature, and digital resources that can facilitate problem exploration. In many educational settings, particularly in underfunded institutions, there may be insufficient resources to support the dynamic and inquiry-based nature of PBL. This lack of resources can limit the scope of problems presented to students, thereby undermining the effectiveness of the PBL experience. Additionally, logistical challenges, such as arranging collaborative group work and access to appropriate facilities, can further complicate PBL implementation.

Instructor training is another critical factor that influences the success of PBL in chemistry education. Unlike traditional teaching methods, PBL requires educators to adopt a facilitator role rather than that of a traditional lecturer. This shift necessitates specific skills, including the ability to guide discussions, assess student collaboration, and foster an environment conducive to inquiry. Many instructors may not have received formal training in PBL methodologies, leading to difficulties in implementation and inconsistent experiences for students. Professional development opportunities are essential to equip educators with the knowledge and skills needed to effectively implement and assess PBL, yet such training may not always be available or prioritized by institutions.

Moreover, student resistance can pose a significant barrier to the successful implementation of PBL. Students accustomed to traditional learning environments may initially struggle with the demands of PBL, where they are expected to take a more active role in their learning. This shift can lead to discomfort, as students may feel unprepared to tackle open-ended problems without the guidance typically provided in lectures. Additionally, some students may perceive PBL as time-consuming or lacking in structure, resulting in reluctance to engage fully in the process. Overcoming this resistance requires effective communication of the benefits of PBL, as well as strategies for gradually integrating PBL into the curriculum to help students acclimate to this new learning model.

Comparison of research results with previous research

Previous research has consistently indicated that PBL leads to improved student engagement and motivation. For example, Hmelo-Silver (2004) found that students participating in PBL environments exhibited higher levels of intrinsic motivation compared to those engaged in traditional lecture-based instruction. This aligns with the findings of the current study, which similarly highlights increased motivation among students when faced with real-world problems that require active participation and collaboration. Both studies underscore the transformative potential of PBL to create more engaging and relevant learning experiences.

Furthermore, the current research corroborates findings from Savin-Baden (2000), which suggested that PBL enhances critical thinking and problem-solving skills. By analyzing the experiences of students in chemistry courses, this study demonstrates that PBL fosters a deeper understanding of chemical concepts and equips students with the ability to apply this knowledge in practical contexts.

The emphasis on inquiry-based learning in both studies highlights a shared recognition of PBL's effectiveness in promoting higher-order thinking skills essential for success in science.

However, this research also identifies gaps not fully addressed in prior studies, particularly regarding the challenges faced during PBL implementation. While previous literature has focused on the positive outcomes associated with PBL, there has been limited exploration of the practical hurdles encountered by educators, such as resource constraints and the need for professional development. This research reveals that these challenges can significantly impact the effectiveness of PBL, suggesting that future studies should delve deeper into strategies for overcoming such obstacles to ensure successful implementation.

Additionally, the current study emphasizes the role of student resistance to PBL, a theme that has received less attention in earlier research. While the literature often highlights the benefits of PBL, understanding and addressing student hesitance can be crucial for facilitating a smoother transition to this learning model. By documenting the experiences of students who initially struggle with the PBL approach, this research contributes valuable insights into how educators can better support students in adapting to new instructional methods.

4. CONCLUSION

This research on Problem-Based Learning (PBL) in chemistry education has illuminated the transformative potential of this pedagogical approach in enhancing student engagement, motivation, and critical thinking skills. The findings underscore the effectiveness of PBL in fostering a deeper understanding of chemical concepts by immersing students in real-world problems that require collaborative inquiry and practical application. Through this active learning framework, students not only grasp theoretical knowledge more effectively but also develop essential skills that are crucial for success in both academic and professional realms. This research contributes to the growing body of literature on innovative teaching strategies in science education. It encourages ongoing dialogue and exploration into the adaptability of PBL across various educational contexts, including online and hybrid learning environments. Future research should continue to investigate the long-term impacts of PBL on student learning and retention, as well as its potential for interdisciplinary connections within the curriculum. Ultimately, as educational paradigms shift towards more interactive and student-centered approaches, Problem-Based Learning stands out as a powerful tool for enriching chemistry education. By embracing PBL, educators can not only elevate the teaching and learning experience but also equip students with the skills necessary to navigate the complexities of the modern world, fostering a new generation of scientifically literate individuals prepared to tackle pressing global challenges.

REFERENCES

Al Kadri, H. M. F., Al-Moamary, M. S., & van der Vleuten, C. (2009). Students' and teachers' perceptions of clinical assessment program: A qualitative study in a PBL curriculum. *BMC Research Notes*, *2*, 1–7.

Almulla, M. A. (2020). The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning. *Sage Open*, *10*(3), 2158244020938702.

Berger, R., Woodfin, L., & Vilen, A. (2016). *Learning that lasts: Challenging, engaging, and empowering students with deeper instruction*. John Wiley & Sons.

Bowen, C. W. (2000). A quantitative literature review of cooperative learning effects on high school and college chemistry achievement. *Journal of Chemical Education*, *77*(1), 116.

Chen, M., Jeronen, E., & Wang, A. (2020). What lies behind teaching and learning green chemistry to promote sustainability education? A literature review. *International Journal of Environmental Research and Public Health*, *17*(21), 7876.

Connolly, P. (2007). *Quantitative data analysis in education: A critical introduction using SPSS*. Routledge.

Dunning, D., Heath, C., & Suls, J. M. (2004). Flawed self-assessment: Implications for health, education, and the workplace. *Psychological Science in the Public Interest*, *5*(3), 69–106.

Fatokun, J. O., & Fatokun, K. V. F. (2013). A problem based learning (PBL) application for the teaching of mathematics and chemistry in higher schools and tertiary education: An integrative approach. *Educational Research and Reviews*, *8*(11), 663.

Gilbert, J. K. (2006). On the nature of "context" in chemical education. *International Journal of Science Education*, *28*(9), 957–976.

Gürses, A., Açıkyıldız, M., Doğar, Ç., & Sözbilir, M. (2007). An investigation into the effectiveness of problem-based learning in a physical chemistry laboratory course. *Research in Science & Technological Education*, *25*(1), 99–113.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*, 235–266.

Hung, W., Dolmans, D. H. J. M., & Van Merriënboer, J. J. G. (2019). A review to identify key perspectives in PBL meta-analyses and reviews: trends, gaps and future research directions. *Advances in Health Sciences Education*, *24*, 943–957.

Jansson, S., Söderström, H., Andersson, P. L., & Nording, M. L. (2015). Implementation of problem-based learning in environmental chemistry. *Journal of Chemical Education*, *92*(12), 2080–2086.

Kalpana, T. (2014). A constructivist perspective on teaching and learning: A conceptual framework. *International Research Journal of Social Sciences*, *3*(1), 27–29.

Khasawneh, E. M. (2016). *Examining the effect of inquiry-based learning vs. traditional lecture-based learning on critical thinking skills and students' achievement in college algebra*.

Malmia, W., Makatita, S. H., Lisaholit, S., Azwan, A., Magfirah, I., Tinggapi, H., & Umanailo, M. C. B. (2019). Problem-based learning as an effort to improve student learning outcomes. *Int. J. Sci. Technol. Res*, *8*(9), 1140–1143.

Mataka, L. M. P. (2014). *Problem-based learning (PBL) in the college chemistry laboratory: Students' perceptions of PBL and its relationship with attitude and self-efficacy beliefs*. Western Michigan University.

Nardi, P. M. (2018). *Doing survey research: A guide to quantitative methods*. Routledge.

Newman, M., Ambrose, K., Corner, T., Evans, J., Morris-Vincent, P., Quinn, S., Stephenson, J., & Vernon, L. (2003). *Evaluating Educational Impact: The Approach Followed by the Project on the Effectiveness of Problem Based Learning (PEPBL).*

Onwuegbuzie, A. J., & Leech, N. L. (2006). Linking research questions to mixed methods data analysis procedures. *The Qualitative Report*, *11*(3), 474–498.

Petrova, E., Dewing, J., & Camilleri, M. (2016). Confidentiality in participatory research: Challenges from one study. *Nursing Ethics*, *23*(4), 442–454.

Rahman, T., & Lewis, S. E. (2020). Evaluating the evidence base for evidence-based instructional practices in chemistry through meta-analysis. *Journal of Research in Science Teaching*, *57*(5), 765–793.

Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. *The SAGE Handbook of Qualitative Research in Psychology*, *2*(17–37), 25.

Trisdiono, H., Siswandari, S., Suryani, N., & Joyoatmojo, S. (2019). Multidisciplinary integrated project-based learning to improve critical thinking skills and collaboration. *International Journal of Learning, Teaching and Educational Research*, *18*(1), 16–30.

Wilson, B. G., & Novak, K. (2017). Constructivism for active, authentic learning. In *Trends and issues in instructional design and technology* (pp. 99–111). Routledge.