JOURNAL OF MULTIDISCIPLINARY SCIENTIFIC KNOWLEDGE

Vol. 01, Issue 02 June 2026

Literature Review of Science Teaching Best Practices to Improving Learning Outcomes of Converger, Diverger, Assimilator and Accommodator

Joseph P. De Vera[1]

Received:- 11/06/2026,Revised:- 12/07/2026, Accepted:- 21/07/2026, Published:- 29/07/2026

Abstract

Effective science teaching requires understanding how students learn, particularly in diverse classrooms. Kolb's Experiential Learning Theory provides a useful framework by identifying four learning styles: Converger, Diverger, Assimilator, and Accommodator. This literature review examines effective science teaching practices for biology learners based on these styles and their relationship to Kolb's four learning stages: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. Using a qualitative research design and thematic analysis of secondary sources, including scholarly articles, research studies, and academic reports, the review identifies instructional strategies suited to each learning style. Convergers tend to benefit from learning by doing inquiry-based activities, real-world problem solving, laboratory experimentation, and collaborative tasks. Divergers learn effectively through reflective and collaborative activities such as brainstorming, peer teaching, and reflective group discussions. Assimilators prefer structured theoretical content, lectures, visual aids, and theory-driven instruction. In contrast, Accommodators excel through hands-on experiences, interactive simulations, fieldwork, and practical activities. The findings emphasize the importance of differentiated instruction, instructional variety, and holistic engagement throughout Kolb's learning cycle. Aligning teaching strategies with learners' cognitive preferences and experiential strengths can improve students' comprehension, engagement, and retention. Overall, the review demonstrates that biology learners benefit when instruction is flexible and responsive to different learning styles. Rather than relying on a single teaching method, science educators should incorporate diverse strategies that allow students to experience, reflect, conceptualize, and actively apply knowledge. This approach can create more inclusive and effective biology learning environments.

Keywords: Kolb's Experiential Learning Theory, learning styles, diverger, converger, assimilator, accommodator

[1]Master of Arts (Biology), Philippine Christian University,
Email ID: josephdevera.dlabc@gmail.com, Orcid ID: 0009-0007-7484-7422

Introduction

Recent studies highlight the need for greater implementation of experiential learning strategies in science education Tazkiah, Mulyani and Rahardjo, (2021) found that Kolb's model is underutilized in teacher training programs, despite its potential for improving student comprehension and retention. To address this gap, integrating the model into science pedagogy is recommended. Research indicates that when educators design Lessons aligned with students' preferred learning styles, performance and engagement significantly improve (Rohmanawati, Kusmayadi and Fatriana, 2021).

Science education benefits significantly from aligning teaching strategies with students' diverse learning styles, particularly in biology, where conceptual understanding and practical application are essential. Kolb's Experiential Learning Theory (ELT) provides a framework that categorizes learners into four distinct styles: Converger, Diverger, Assimilator, and Accommodator. Each learning style corresponds to a specific combination of Kolb's four learning stages—Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. Research suggests that adapting science teaching practices to these styles can enhance student engagement, comprehension, and overall learning outcomes (Itasari, Pramudya,
and Slamet, 2021).

Kolb's ELT emphasizes that learning is a cyclical process in which individuals develop preferences for certain stages, leading to distinct learning styles. Convergers excel in problem- solving and practical applications of theories, favoring Abstract Conceptualization and Active Experimentation. Divergers are imaginative and excel in viewing situations from multiple perspectives, engaging in Concrete Experience and Reflective Observation (Rohmanawati, Kusmayadi, and Fatariana, 2021). Assimilators prefer structured, logical information processing, prioritizing Abstract Conceptualization and Reflective Observation. Accommodators, on the other hand, rely on intuition and hands-on experiences, emphasizing Concrete Experience and Active Experimentation (Wu & Wang, 2025).

For Convergers, problem-based learning (PBL) has been identified as an effective approach. PBL presents students with real-world challenges that require the application of theoretical knowledge, aligning well with Convergers' strengths in Abstract Conceptualization and Active Experimentation. Research by Nitriani, Darsikin and Saehana, (2022) demonstrated that PBL enhances critical thinking and problem-solving abilities among science students, making it a valuable instructional tool for Convergers. Moreover, case studies and Simulations provide opportunities for Convergers to test hypotheses and refine their analytical skills.

Divergers benefit from collaborative and discussion-based learning environments that encourage multiple perspectives. Group discussions, reflective journaling, and brainstorming sessions allow Divergers to engage in Reflective Observation and Concrete Experience. A study by Suwarna and Muhammad (2023) emphasized that cooperative learning strategies, such as peer teaching and debate formats, improve conceptual understanding for Divergers by enabling them to analyze and synthesize information through discussion. Encouraging creativity in assessments, such as requiring students to create concept maps or models, further enhances their engagement and knowledge retention (Anwar, Saiman, and Zaki, 2024).

Assimilators, who favor structured and logical learning methods, thrive in environments that provide comprehensive explanations and theoretical frameworks. Traditional lectures, supplemented with visual aids such as flowcharts and diagrams, cater to their preference for Abstract Conceptualization and Reflective Observation. Anwar, Saiman, and Zaki (2024) found that concept mapping improves information retention among science students, particularly Assimilators, by organizing knowledge into hierarchical structures. Similarly, research by Eng and Daneil (2021) suggested that incorporating data analysis and research-based Assignments helps Assimilators develop a deeper understanding of scientific principles.

Accommodators, who learn best through direct experience, benefit from hands-on activities such as laboratory experiments, fieldwork, and interactive simulations. Hands-on learning aligns with their reliance on Concrete Experience and Active Experimentation. Research by Guevarra and Panoy (2022) found that students who engage in laboratory-based inquiry show higher retention rates in biology courses. Additionally, project-based learning, where students design and conduct their own experiments, has been shown to increase motivation and practical understanding among Accommodators (Zahiroh & Masduki, 2024). Virtual reality (VR) and augmented reality (AR) simulations further enhance experiential learning by immersing students in interactive environments, reinforcing scientific concepts through direct engagement (Bechara,2022).

While tailoring instructional methods to individual learning styles enhances engagement and comprehension, fostering adaptability in students is also crucial. Encouraging students to engage in all stages of Kolb's learning cycle promotes cognitive flexibility and a more comprehensive grasp of scientific concepts. Research by Alharbi et al. (2024) suggested that students who develop a balance across all learning styles demonstrate greater problem-solving abilities and adaptability in complex scientific contexts. Moreover, integrating metacognitive strategies, such as self-reflection exercises and guided questioning, has been shown to help students expand beyond their dominant learning preferences (Cam, Arslan and Cigdemoglu,2022).

Thus, implementing science teaching best practices based on Kolb's learning styles significantly improves learning outcomes in biology education. By incorporating problem-solving approaches for Convergers, discussion-based methods for Divergers, structured theoretical frameworks for Assimilators, and experiential learning activities for Accommodators, educators can create a more inclusive and effective learning environment. Additionally, promoting cognitive flexibility ensures that students develop well-rounded problem-solving skills essential for scientific inquiry. Continued research on integrating learning styles in science pedagogy will further refine teaching methods, ultimately enhancing student success and engagement in biology education.

The study aims to explore the science teaching best practices to improve learning outcomes of converger, diverger, assimilator, and accommodator. Specifically, this seeks to answer the following questions:

1. What are the best practices of Biology learners in terms of Kolb's learning style as converger, diverger, assimilator and accommodator?

2. What learning stages of each learning style are best demonstrated in terms of
    2.1 Concrete Experiences
    2.2 Reflective Observation
    2.3 Abstract Conceptualization
    2.4 Active Experimentation

3. Based on findings, what science teaching best practices to improve learning outcomes can be proposed?

2. Materials and Methods

2.1 Research Design

This study employed a qualitative research design which utilized secondary sources to gather relevant literature and data. It relied on existing studies, journal articles, and scholarly publications to analyze the best practices of Biology learners based on Kolb's learning styles—converger, diverger, assimilator, and accommodator. Thematic analysis was applied to identify patterns and insights related to how each learning style demonstrates concrete experiences, reflective observation, abstract conceptualization, and active experimentation. Since the study did not involve primary data collection, its findings were derived from an extensive review of existing research to propose science teaching best practices that could improve learning outcomes.

2.2 Data Gathering Procedure

Since this study utilized secondary sources, the data gathering procedure involved collecting relevant literature, studies, and scholarly articles instead of conducting primary data collection. The researcher identified credible sources from academic databases, peer-reviewed journals, and official reports that discussed the perceptions and challenges faced by science teachers in implementing best practices tailored to the learning styles of convergers, divergers, assimilators, and accommodators. A systematic search strategy was employed, and used specific keywords and inclusion criteria that ensured the relevance and reliability of the selected materials. When relevant sources were identified, the researcher evaluated their quality and credibility based on factors such as publication date, peer-review status, and methodological rigor. Only sources published within the last six years and those that contributed valuable insights into Kolb's learning styles and science teaching best practices were included. The researcher then organized and categorized the collected data, classified the findings according to themes that aligned with the study's objectives, particularly in terms of the learning stages demonstrated by each learning style—concrete experiences, reflective observation, abstract conceptualization, and active Experimentation.

Following data collection, thematic analysis was employed to systematically examine the literature, identify the patterns, recurring themes, and gaps in existing research. This process allowed for a comprehensive synthesis of findings, leading to the formulation of well-informed conclusions regarding effective science teaching practices that catered to different learning styles. Finally, the researcher interpreted and presented the findings in relation to the study's objectives, ensuring that the recommendations for improving science teaching practices were grounded in empirical evidence.

2.3 Data Analysis

This study utilized thematic analysis that rigorously examined data obtained from secondary sources. Thematic analysis facilitated the identification of recurring patterns and significant insights within scholarly articles, research studies, and academic reports, offering a systematic approach to understanding how differentiated instruction aligned with various cognitive styles. The data collection process began with an extensive review of literature from reputable sources, ensuring accurate and detailed documentation of findings relevant to the study.

The selected sources were subjected to multiple readings to enhance the researcher's

familiarity with the data, allowing for the initial identification of key patterns and emerging themes.

Upon completion of the familiarization process, the researcher commenced coding, a systematic method that entailed assigning labels to words, phrases, or concepts that conveyed significant insights into best practices of biology learners and the learning strategies of each learning style. The coding process was conducted inductively, allowing themes to emerge organically from the collected literature rather than being predetermined. This approach ensured a comprehensive examination of all pertinent discussions, including insights which were not directly aligned with the study's research questions but provided a valuable contribution to understanding best practices in science education. After completion of coding, related codes were organized into clusters based on conceptual similarities and relevance to the study's objectives. These clusters facilitated effective data organization, emphasizing both common findings and differences across various studies.

Subsequent analysis involved extracting broader themes from these clusters, which elucidated the underlying patterns characterizing the implementation of best practices for students with varying cognitive styles. Thematic refinement involved an ongoing evaluation and restructuring of coded data to ensure clarity, coherence, and precision. The identified themes were then analyzed in relation to existing theoretical frameworks, facilitating a deeper contextualization of the findings.

3. Results

3.1 Best Practices of Biology Learners in Terms of Kolb's Learning Style

3.1.1 Convergers

The thematic analysis revealed several key practices that benefit Convergers in biology education. Convergers, who excel in practical application and problem-solving, demonstrated enhanced learning outcomes through specific educational approaches.

Table 3.1 Best Practices for Convergers Learning Style in Biology Education

Author/s	Best Practices	Keywords	Codes	Themes
1. Winarso & Toheri, 2021	Experimentation with innovative ideas and the application of theoretical concepts to practical scenarios.	Experimentation, innovative ideas, theoretical concepts, practical application	Practical, Innovation, Lab-based learning and Engagement through experience	
2. Ridzal, 2024	Integrate experiments and real-world problem scenarios.	Laboratory, real-world, problem-solving		
3. Tian & Ng, 2024	Active experimentation while promoting a deeper engagement	Active experimentation, deeper engagement,		

	with the subject matter through real-world contexts.	real-world		
4. Tu, Lo & Zhang, 2023	In the United States, educational practices frequently prioritize active learning and experiential education.	Active learning, experiential education		
5. Tazkiah, Mulyani, & Rahardjo, 2021	In the Philippines, initiatives that foster inquiry-based learning and utilize low-cost experimental setups enable students to participate in hands-on activities despite limited resources.	Inquiry-based, low-cost, hands-on	Inquiry Approach	Experimental Learning or "Learning through Doing"
6. Yang et al., 2023	Implementing inquiry-based learning	Inquiry-based learning		
7. Lakshmi, Praytino & Indrowati, 2023	Convergers who demonstrate proficiency in problem-solving and practical application, engage actively in laboratory experiments and inquiry-based learning, resulting in a more profound understanding of scientific principles.	Inquiry-based, Lab Understanding		
8. Syaputra & Mulyono, 2021	In Finland, offering flexible curricula that facilitate experiential learning opportunities.	Flexible curriculum, experiential learning		

9. Poree, 2023	Finnish schools frequently integrate outdoor education and practical projects into their science curricula, allowing Convergers to interact with biological concepts in natural environments.	Outdoor education, practical projects, biology	Nature-based Learning and Practical projects	
10. Ezzeddine et al., 2023	Convergers who demonstrate proficiency in practical application and problem-solving, gain advantages from engaging in laboratory experiments and real-world problem scenarios.	Lab experiments, problem solving		
11. Songkram et al., 2024	Collaborative projects involving problem solving tasks.	Collaborative, problem-solving	Group Work, Critical Thinking and Civic Engagement	Collaborative Learning
12. Syatriana & Akib, 2024	In the Philippines, collaboration with local communities and organizations offer students opportunities to engage in environmental projects.	Community, Collaboration, Environment		

According to the analysis, when Convergers participate in activities that highlight applying theoretical ideas to real-world scenarios, they exhibit strong learning outcomes. This is consistent with Kolb's experiential learning theory, which characterizes convergers as learners who are highly skilled at active experimentation and abstract conceptualization. They particularly gain from educational settings that integrate "learning through doing," like practical projects, lab experiments, and real-world simulations. By applying theoretical knowledge to real-world issues, these activities help

Convergers internalize it and strengthen their conceptual understanding through hands-on practice. Furthermore, the results imply that group-based activities that promote problem-solving and critical thinking also help Convergers meet their learning objectives. Even though they are frequently described as independent learners, it seems that their problem-solving skills are improved when structured, goal-oriented collaboration is incorporated. The execution of creativity and the testing of new ideas emerged as beneficial practices for Convergers. Winarso and Toheri (2021) elaborated further, detailing how Convergers prosper in environments where they can test hypotheses and apply scientific principles to practical situations. Ridzal (2024) noted the usefulness of combining laboratory exercises with real-life challenges in terms of the identified benefits for Convergers. The inclusion of inquiry-based learning activities resulted in a noticeable increase in Convergers' participation and understanding. Yang et al. (2023) highlighted that inquiry-based learning allows Convergers to apply their strong reasoning abilities as they investigate biological phenomena hands-on. As a result, many of them have had more positive learning results. Songkram et al. (2024) reported that group problem-solving activities helped Convergers to build better practical ideas through the discourse with their peers.

The Convergers' learning experiences are shaped by sociocultural factors, as well as by their educational setting. In the case of the United States, 'active learning' and 'experiential education' are recurrent features of the American educational system, which attempts to fit Convergers' needs and preferences (Tu et al. 2023). To some extent, these exposed learners are also supported by Finnish educational systems, which include curricula that allow for experiential learning (Syaputra & Mulyono, 2021). Primary education in Finland also encompasses outdoor education and various hands-on projects within the framework of science subjects, thus enabling

Convergers to appreciate the application of biological concepts in real-world situations (Poree, 2023).

In the Philippines and other developing countries, in an increasingly resource constrained environment, programs aimed at enhancing inquiry-based learning and involving low-cost experimental practices offer participants who possess a Converger learning style an opportunity to actively engage with the learning process (Tazkiah et al., 2021). Community and local organization partnerships give students the chance to take part in environmental projects which demonstrate the integration of classroom knowledge with practical applications and assist Convergers in problem solving and the application of learning (Syatriana & Akib, 2024).

3.1.2 Divergers

Divergers, characterized by their imaginative and reflective abilities, benefit from distinct educational practices in biology education. The thematic analysis identified several approaches that enhance learning outcomes for this group.

Table 3.2 Best Practices for Divergers Learning Style in Biology Education

Author/s	Best Practices	Keywords	Codes	Themes
1. Ozdemir et al., 2024	Demonstrate strength in brainstorming and group discussions.	Brainstorming, group discussions		

2. Itasari et al., 2021	Integrate group discussions, case studies, and avenues for creative expression into their teaching methods to support Divergers in biology education.	Group discussion, case studies, creative expression	Collaborative Thinking, Socratic and Critical Methods	Collaborative & Reflective and Imaginative Learning
3. Cigdemoglu et al., 2022	Classrooms in Western countries that incorporate collaborative learning and prioritize critical thinking. Educators may utilize Socratic seminars or group projects to facilitate students' analysis of biological phenomena from multiple perspectives.	Collaboration, critical thinking, seminars		
4. Nitriani et al., 2022	The use of multimedia resources, including documentaries and interactive models, can enhance the imaginative capabilities of Divergers.	Multimedia, Documentaries. Interactive models, imagination	Reflective Thinking, Imaginative	
5. Liu et al., 2024	Creativity and reflection enables educators to assist Divergers.	Creativity, reflection		
6. Ezzeddine et. al., 2023	In the Philippines, community-based projects that tackle environmental issues. Divergers enables them to utilize their	Community-based, environmental issues, imagination		

	reflective and imaginative strengths to address real-word issues in their communities.		Reflective Thinking, Imaginative	
7. Commeford et. al., 2021	The research identified diverse instructional styles, including interactive lectures and modeling instruction, which emphasize student engagement and reflection – key aspects appealing to Diverger learners.	Interactive lectures, modeling instruction, student engagement, reflection		
8. Xue F. et. al., 2023	This study compared the effectiveness of virtual reality (VR), desktop applications, and traditional slide lectures in teaching food microbiology. Results showed that VR facilitated longer visual attention and a higher sense of immersion, potentially benefiting Diverger learners who thrive in imaginative and experiential settings.	Virtual reality, visual attention, immersion, imaginative, experiential		
9. Celik & Ergin, 2022	Integration of case studies and open-ended projects.	Case studies, open-ended projects	Critical, Inquiry, Integrated Learning	Integrated Inquiry-based Learning
10. Guevarra & Panoy, 2022	Interdisciplinary projects that combine biology with the arts and social studies,	Interdisciplinary, creative, contextual		

	enabling Divergers to engage with the subject matter in a creative and contextual manner.			

The results show that environments that prioritize contextual, inquiry-driven exploration as well as collaborative engagement are ideal for students with a Diverger learning style. Divergers are known for their propensity for observation, introspection, and idea generation. They also frequently favor educational opportunities that require both creative problem-solving and social interaction.

One of the main conclusions emphasizes how adept Divergers are at group discussions and brainstorming, which validates their propensity for reflective and cooperative learning. Divergers can process information from various viewpoints, have critical conversations, and hone their understanding through shared insights thanks to these activities. A key component of Divergers' preferred learning style is the environment created by group interactions, which allows them to express their thoughts and consider different points of view.

Özdemir et al. (2024) observed that group discussions and brainstorming sessions seemed to work particularly well for Divergers. They noted that Divergers performed best in teams within a group setting which valued multiple viewpoints. Case studies and open-ended projects also further support the learning of Divergers by helping them integrate creative thinking with the biological concepts (Çelik & Ergin, 2022).

Divergers' engagement with biology content is aided greatly by the use of multimedia resources. Nitriani et al. (2022) showed that documentaries, interactive models, and even whole class learning using the visual method of teaching called whole-class teaching as he visual instruction helped Divergers link abstract biological concepts with tangible exemplars. Liu et al. (2024) also stressed that learning environments which foster creativity and reflective thinking are necessary for educators to effectively help Divergers realize their inherent potentials in biology.

Practices which combine group discussion, case study, and some form of creative practice are particularly effective for Divergers (Itasari et al., 2021). Research projects on the ecological consequences of human interventions stimulate Divergers to confront real-world problems and devise novel strategies to solve them (Hydrie & Naqvi, 2021). In Western educational settings, the synergistic integration of cooperative learning with higher-order psychosocial teaching thinking skills provided the most conducive atmosphere for Diverger learners. Teachers are free to organize Socratic discussions or group work which enable students to look at biological phenomena through a variety of lenses (Çigdemoğlu et al., 2022).

In the Philippines, culturally relevant pedagogy and community-centered environmental projects capture the attention of Diverger students by allowing them to reflect and imagine while connecting learning with their local community (Ezzeddine et al., 2023). These strategies are aimed at increasing engagement and understanding of biological concepts among Diverger learners.

3.1.3 Assimilators

Assimilators, who prefer structured, logical information processing, benefit from educational practices that emphasize theoretical frameworks and systematic analysis. The thematic analysis identified several key approaches that enhance learning outcomes for

this group.

Table 3.3 Best Practices for Assimilators Learning Style in Biology Education

Author/s	Best Practices	Keywords	Codes	Themes
1. Anwar et al., 2024	They demonstrate proficiency in comprehending and structuring information into coherent, logical formats, frequently preferring lectures and readings that offer extensive theoretical frameworks.	Structuring, Lectures, Theoretical	Structured and Systematic	Cognitive Structure and Abstract Learning
2. Alharbi et al., 2024	Providing a structured learning environment with defined objectives and comprehensive resources can improve the engagement and success of Assimilators in biology education.	Structures Environment, Objectives		
3. Effah et al., 2021	The integration of diagrams, charts, and models aids Assimilators in visualizing complex processes, thereby enhancing comprehension.	Visuals, Comprehension, Models		
4. Bawazeer et al., 2022	Facilitating opportunities for independent research and analysis enables Assimilators to explore topics of interest more thoroughly, thereby fostering self-directed leaming.	Independent, Research, Self-directed	Autonomy in Learning, Critical Thinking Analysis	
5. Cam et al., 2022	In the Phil. recent initiatives to integrate research-based leaming and higher-order	Research-based, Higher-order thinking		

	thinking skills into the curriculum have enhanced opportunities for Assimilators to excel.			
6. Enwerekowe et al., 2023	Assignments necessitating critical evaluation of scientific literature are advantageous, as they correspond with Assimilators' inclination towards abstract conceptualization and logical reasoning.	Critical Evaluation, Abstract, Logic	Critical Thinking, Analytical Instruction and Active Intellectual Engagement	Self-directed and Interactive Analytical Instruction
7. Abdul Rabu et al., 2023	Research demonstrates that instructional strategies, including flipped classrooms, academic debates, and research-driven coursework, align with the strengths of Assimilators by facilitating information absorption and analysis prior to application	Debates, Flipped Classroom, Research		
8. Çigdemoğlu et al., 2023	In the Phil., educators who incorporate case studies, Socratic questioning, and independent research projects into their teaching facilitate the development of analytical skills in Assimilators and enhance their comprehension of complex subjects.	Case Studies, Socratic, Analysis		
9. Anwar et al., 2024	Research indicates that American students exhibiting an Assimilator learning style excel in higher	Critical Analysis, Hypothesis		

	education, especially in disciplines such as philosophy, mathematics, and the sciences, where critical analysis and hypothesis testing are integral components.		Abstract Conceptualization & Cognitive Processing	Theoretical & Analytical Learning
10. Çelik & Ergin, 2022	Research indicates that Filipino students exhibiting an Assimilator learning style demonstrate superior performance in academic research, debate, and theoretical disciplines that facilitate logical reasoning and conceptual exploration.	Logical Reasoning Conceptual Exploration		

The findings from this study underscore the distinct learning preferences and cognitive strengths of students who exhibit the Assimilator learning style. Characterized by a strong orientation toward abstract conceptualization and reflective observation, Assimilators are most successful when immersed in learning environments that emphasize structured, theoretical frameworks and logical analysis.

Firstly, Cognitive Structure and Abstract Learning, this theme aligns directly with Abstract Conceptualization, one of the dominant learning modes of Assimilators. These learners prefer to understand complex concepts through organized frameworks and structured information. This help students organize complex biological information logically. Promoting deeper understanding and long-term retention.

Secondly, the data indicate that Self-directed and Interactive Analytical Instruction where learners are encouraged to explore independently, analyze, and engage intellectually. Self- paced learning modules, problem-based learning (PBL) and data interpretation tasks are some of the best practices in biology education. As a result, it empowers learners to engage more deeply by guiding their own intellectual inquiry and reinforces analytical reasoning critical for scientific thinking.

Finally, Assimilators excel when learning is theory-driven and logical. They prefer a clear cause-effect relationship and value scientific reasoning. Incorporating hypothesis-driven experiments, such as virtual or in-lab dissections with accompanying theoretical models, case studies that require diagnosis or logical explanation using biological theory and evaluating research papers are some of the best practices in biology education. These activities and practices support students' ability to connect biological phenomena to abstract models and theories, enhancing their scientific literacy and analytical skills.

Assimilators are best catered to by lectures and readings that give extensive theoretical consideration. Anwar et al. (2024) reports Assimilators to be competent in the understanding and organization of information into coherent and logical patterns. Effah et al. (2021) also reported how diagrams, charts, and models assist an Assimilator in

understanding intricate biological phenomena.
The possibility to conduct independent research and analyses provides avenues for Assimilators to study topics of interest in great detail. Self-directed study opportunities improve engagement and retention of content among Assimilators (Bawazeer et al., 2022). The process of critically analyzing scientific texts is in tandem with an Assimilator's ability to abstract and synthesize information for rationalistic analysis (Enwerekowe et al. 2023).
Biology education is best attended to with clear sets of goals, defined learning materials, and logically structured curricula which increase motivation and achievement in students who identify as Assimilators (Alharbi et al., 2024). In the context of advanced education, American students with an Assimilator learning style perform exceptionally well in philosophy, mathematics and the sciences, as critical analysis and hypothesis testing feature prominently (Anwar et al., 2024).
Instructional approaches such as flipped classrooms, academic debates, and coursework with a strong research component are particularly suitable for the Assimilator learning style since they enable thorough analysis and information evaluation before practical application (Abdul Rabu et al., 2023). In the Philippines, more recent attempts to include research-based instruction and higher-order thinking skills into the curriculum have created new avenues for Assimilators to thrive (Cam et al., 2022). Filipino students with the Assimilator learning style tend to excel in associational logic-based activities such as academic research, debating, and other theoretical disciplines that encourage synergistic reasoning. (Çelik & Ergin, 2022).

3.1.4 Accommodators

Accommodators, who learn best through practical experiences and active experimentation, benefit from hands-on, experiential approaches in biology education. The thematic analysis revealed several effective practices for this learning style.

Table 3.4 Best Practices for Accommodators Learning Style in Biology Education

Author/s	Best Practices	Keywords	Codes	Themes
1. Zahiroh & Masduki, 2024	Accommodators benefit from interactive activities such as experiments, fieldwork, and simulations that allow them to engage directly with the material.	Experiments, Fieldwork, Simulations. Engage		
2. Tu et al., 2023	Research suggests that Accommodators perform well in settings that prioritize	Apprenticeships, Maker Spaces, Simulations	Interactive	

	experiential learning, such as apprenticeships, maker spaces, and simulations that allow them to actively engage with the learning process.		and Experiential Activities	Experiential and Hands-on Learning
3. Winarso & Toheri, 2021	Accommodators, who prefer practical experiences, learn most effectively through interactive activities and experiments.	Practical, Interactive, Experiments		
4. Yang et al., 2023	By creating a dynamic and interactive learning environment, educators can effectively engage Accommodators in the study of biology.	Dynamic, Interactive		
5. Winarso & Toheri, 2021	Accommodators thrive in vocational training programs, hands-on workshops, and entrepreneurship courses that emphasize real-world applications.	Vocational, Hands-on Real-world	Practical Application	
6. Tian & Ng. 2024	The rise of experiential learning initiatives in American higher education, such as co-op programs and internships, further supports Accommodators' preference for active engagement	Experiential Learning, Internship		
7. Gunes M., 2018	Accommodators prefer learning by doing. Incorporating laboratory experiments, fieldwork, and simulations can enhance their engagement and understanding. For	Learning by doing, laboratory experiments, fieldwork, simulations, real-world applications,		

	instance, integrating real-world applications and practical tasks allows these leamers to connect theoretical concepts with tangible experiences.	practical tasks		
8. Abiodun Natalie, 2024	Group discussions and collaborative projects align well with Accommodators' preference for social learning environments. Engaging in team-based activities enables them to explore diverse perspectives and develop a deeper understanding of biological concepts.	Group discussions, collaborative projects, social learning environments, team-based activities	Peer Engagement	Collaborative Learning
9. Chi, Michelen, 2025	The use of peer instruction and problem-based learning scenarios in science classes align with accommodators' active learning preferences.	Peer instruction, problem-based learning, science classes, active learning preferences		
10. Kolb & Kolb, 2017	Accommodators benefit from adaptable learning environments that support various activities like creating learning spaces that can be easily reconfigured for group work, experiments, and discussions.	Adaptable environments, reconfigured		

The analysis of data reveals that Accommodators exhibit a strong preference for learning through experiential and active engagement, distinguishing them from other learner types through their reliance on concrete experience and active experimentation as described in Kolb's experiential learning theory.

The first major theme, Experiential and Hands-on learning, emphasizes learning through direct experience—the cornerstone of the Accommodator's style. These learners thrive when they can interact physically with biological content, rather than just study it

theoretically. Fieldwork, outdoor exploration, lab experiments, interactive simulation and role-playing biological processes are some of the best practices for accommodators in biology education. With this, it deepens understanding through immersion and active involvement. It also builds intuitive understanding of biological processes via direct manipulation.

Accommodators are people-oriented, often excelling in social settings that involve shared problem-solving, group work, or team-based activities. Group labs and team research projects, peer teaching or study groups, discussion-based learning and collaborative design thinking are among the best practices for them in biology education. These activities enhance learning through dialogue and social interaction. It builds communication and teamwork skills essential for scientific careers and reinforces knowledge by explaining and defending ideas to peers.

Experiments, fieldwork, and simulations allow primary Accommodators Direct Activists engaging with biological concepts. Zahiroh and Masduki (2024) showed that Accommodators make the most out of teaching strategies that facilitate engagement with the subject taught. Biology lessons are designed to be dynamic and interactive which actively engages Accommodators (Yang et al., 2023).

As Winarso and Toheri (2021) noted, Accommodators' preferences are: vocational training programs, workshops with substantial hands-on components, and entrepreneurship subjects focused on real-life application. Research indicates Accommodators tend to thrive when provided opportunities for experiential learning such as through apprenticeships, maker spaces, and active simulations of real-life tasks (Tu et al., 2023).

Project-based learning assists Accommodators in skill development through the application of theoretical knowledge with real-life tasks. The growing number of experiential learning programs in American higher education, including co-ops and internships, is beneficial for Accommodators who favor being active participants in the learning process (Tian & Ng, 2024). Technical vocational education in the Philippines has science laboratory classes, business simulation classes, and other technical-vocational courses that allow learners to acquire practical competencies and supplemental skills.

3.2 Learning Stages of Each Learning Styles

3.2.1 Concrete Experience

The analysis of literature revealed distinct patterns in how different learning styles engage with
concrete experiences in biology education.

Table 3.5 Learning Stages - Concrete Experiences by Learning Style

Author/s	Best Practices	Learning Style	Keywords	Codes	Themes
1. Tsekhmister et al., 2023	Research demonstrates that Divergers perform optimally in learning environments that allow for	Diverger	Observation, Experiential Learning	Experientia l	

	observation and information gathering prior to making judgments, thus highlighting the effectiveness of experiential learning methodologies for this group.				
2. Syatriana & Akib, 2024	Divergers benefit from team-based projects, design thinking sessions, and community engagement initiatives that enhance their ability to process information holistically.	Diverger	Teamwork, Design thinking, Community Engagement	Experiential	Experiential Community Engagement with Collaborative
3. Syatriana & Akib, 2024	concrete experiences such as immersive storytelling, museum visits, and cultural immersion activities help vergers develop their ability to view situations from multiple perspective	Diverger	Immersion, storytelling, cultural exposure, perspective		
4. Syatriana & Akib, 2024	concrete experiences for Accommodator	Accommodator	Hands-on, direct engagement,	Direct Experience	

	s a timally illustrated through hands-on activities, dire engagement, and dynamic learning environments.		dynamic environments		
5. Suwarna & Muhammad, 2023	In educational settings, Accommodators benefit from immersive workshops, practical skill-building exercises, and entrepreneurial training programs than courage innovation and adaptability	Accommodator	Innovation, practical training, adaptability	Problem Solving and Innovation	Hands-on Experience and Project-Based Learning
6. Sari et al., 2023	Research highlights that project-based learning, leadership simulations, and real-world internships offer valuable concrete experiences that support accommodators preference for action-oriented	Accommodator	Projects, leadership, real-world practice		
7. Suwarna & Muhammad, 2023	Accommodators demonstrate proficiency in training lecision-making	Accommodator	Trial and error, interactive problem-solving		

	activities				
8. Tazkiah et al., 2021	Research indicates that in STEM education, concrete experiences, including laboratory experiments and interactive simulations, improve Convergers' capacity to understand complex technical information and enhance their problem-solving strategies.	Converger	Laboratory Experiments, simulations, problem-solving	Simulations	Problem Solving and Reflective Learning
9. Rayavaram et. Al., 2024	In practical applications, educational tools that incorporate experiential learning principles, such as the CryptoEL platform designed for K-12 cryptography education, utilize the full cycle of Kolb's model, including Concrete Experience. This approach allows	Converger	Simulations, Interactive Scenarios		

	learners, including those with a Converging style, to engage with real-world simulations and interactive scenarios, providing concrete experiences that they can abstract and experiment upon.				
10. Wangdi et. Al, 2020	In a study on students' learning styles, it was noted that "Kolb's model considers concrete experience as the basis for observations and reflections," for converger which are essential for forming abstract concepts and generalizations	Converger	Observations and reflections	Reflective	
11. Syaputra & Mulyono, 2021	Research suggests that Assimilators excel in educational settings where they can explore theoretical models before	Assimilator	Theoretical models, labs, simulation, data, analytical thinking		

	engaging in hands-on applications. Studies indicate that laboratory-based learning, computer simulations, and data-driven research projects provide valuable concrete experiences that support their preference for analytical thinking			Research-based and Data Analysis	Structured, Evidence-based and Analytical Learning
12. Suwarna & Muhammad. 2023	In higher education, Assimilators gain from research-oriented assignments, case study evaluations, and academic discussions that enable them to integrate information prior to its application to practical issues	Assimilator	Research, case studies, integration, theory application		
13. Syatriana & Akib, 2022	In corporate training, Assimilators participate effectively in structured learning modules that	Assimilator	Data, research, policy analysis, logic		

	incorporate data analysis, market research, and policy evaluations, allowing them to develop expertise in a logical and systematic way.				

Concrete Experience (CE) involves learning by doing, feeling, and directly participating in events or activities. This stage is the foundation of experiential learning and is critical in science education, where real-world relevance and hands-on practice are essential.

The findings of this study reveal that divergers' common themes are experiential community engagement and collaborative learning whose learning preferences are observing, gathering information, reflecting on meaning and connecting with human/social context. Best practices include community-based science projects like environmental conservation, field visits to biodiversity parks, collaborative activities like team reflection after data collection and finally storytelling and cultural perspectives in biology like traditional knowledge of medicinal plants.

Divergers thrive when learning is context-rich, people-oriented, and emotionally engaging. This makes community engagement and group reflection ideal ways to embed biological knowledge meaningfully. Divergers, as a different category, learn best from experiences that are personally meaningful, such as storytelling or evoking emotional connections. Tsekhmister et al. (2023) found that learners require observation and information-gathering opportunities before forming conclusions, which is why they encountered the most success. Syatriana and Akib (2024) highlighted that team projects, design thinking, and community service help Divergers process information more inclusively.

Accommodator's hands-on experience and project-based learning theme reveals that their learning preferences are action-driven, learn by trial-and-error. Best practices for project-based learning (PBL) is designing a micro-ecosystem or composting unit. DIY experiments and lab activities can also be done like testing soil pH. Field explorations like water sampling and ecological surveys and prototype creation like building models of cellular structures or processes are also best practices in biology education. Accommodators engage best with immediate, sensory, and practical challenges. Projects and hands-on activities allow them to learn actively and iteratively, making biology real and dynamic. Accommodators excel in hands-on tasks with active participation such as in dynamic learning settings (Syatriana & Akib, 2022). They also gain from value-based learning through project-based learning, leadership simulations, and internships in real-life settings (Sari et al., 2023). In classroom contexts, Accommodators are assisted by fully participatory workshops, self-skill training workshops, and entrepreneurial training that promote creative and flexible thinking (Suwarna & Muhammad, 2023).

Problem-solving simulations and reflective learning are the common themes revealed from the study in concrete experience for convergers. The learning preferences include

solving problems logically, applying ideas practically, and structured experimentation. Common practices in biology education would include simulations of real-world biological problems, scientific investigations with hypothesis-driven structure, case studies like solving a clinical scenario using biological knowledge and finally, reflective discussion on strategy effectiveness
after task completion. Convergers need experiences that are goal-oriented and intellectually stimulating. Simulations provide a realistic setting for testing their logic and decision-making in biology, while reflection enhances learning transfer.
For Convergers, hands-on engaging activities paired with well-defined goals yield the greatest result. Tazkiah et al. (2021) found that interactive simulations and laboratory experiments better assist Convergers in comprehending and solving sophisticated technical challenges. In the workplace, case studies and scenario-based learning alongside content specific to their industry allows Convergers to integrate theoretical knowledge with practical experience.
Assimilators' theme under concrete experience are structured, evidence-based, and analytical learning whose focus are on concepts, models, logical thinking and structured and theoretical depth. Best practices in biology education would include lab-based activities with a focus on controlled observation and inference, data analysis of experimental results like graphing population growth, scientific literature reviews like reading journal articles on genetic engineering and theory-to-practice frameworks like applying biological models to understand
ecological systems. Though Assimilators lean toward abstract learning, engaging them in structured experiences like data collection, analysis, and theory testing helps ground learning in real biological evidence while honoring their preference for intellectual rigor. For Assimilators, concrete experiences are most efficient when paired with a structured classroom environment that requires a clear demonstration of logic and reasoning. Syaputra and Mulyono (2021) demonstrated that laboratory work, simulations, and research projects utilizing data streamline
the learning process most effectively for analytical thinkers, such as Assimilators, and therefore provides great value. Course-based pragmatic assignments where students engage in discussion prior to actual application helps Assimilators integrate diverse pieces of information while evaluating them through a practical filter (Suwarna & Muhammad, 2023).

3.2.2 Reflective Observation

The thematic analysis revealed distinctive patterns in how each learning style engages in reflective observation during the learning process.

Table 3.6 Learning Stages - Reflective Observation by Learning Style

Author/s	Best Practices	Learning Style	Keywords	Codes	Themes
1. Ridzal, 2022	Research indicates that Convergers effectively process experiences by reflecting on problem-solving strategies,	Converger	problem-solving. evaluation, improvement		

	evaluating the effectiveness of their decisions, and identifying areas for improvement.			Reflection to Improve Problem-solving	Reflective Thinking
2. Poree, 2023	Reflective observation in STEM education is incorporated through post-laboratory discussions, technical debriefings, and data interpretation exercises, which improve the refinement of problem-solving techniques.	Converger	post-laboratory discussions, debriefing. data interpretation		
3. Rascón Jr., 2023	Reflective observation for Divergers is optimally exhibited through introspective exercises, storytelling reflections, and discussions that facilitate perspective sharing.	Diverger	introspection, storytelling, sharing	Emotional and Social Reflection	
4. Nuthasanah et al., 2021	In creative disciplines, reflective observation is incorporated through portfolio reviews, artistic critiques, and personal reflection essays that promote deeper emotional engagement.	Diverger	portfolio reviews, artistic critiques, personal reflection		
5. Magodi et al., 2023	Research indicates that in vocational education, practical experiences such as internships, apprenticeships, and fieldwork enable Accommodators to enhance their skills in	Accommodator	fieldwork, internships, apprenticeships	Hands-on	

	dynamic settings.			Reflective Feedback	
6. Donald Schon, 2022	During the Reflective Observation phase, which emphasizes watching and reflecting on experiences, Accommodators may face challenges. Their natural inclination is towards action and experimentation, making prolonged periods of reflection less comfortable. However, engaging in reflective observation is crucial for Accommodators to fully benefit from the experiential learning cycle. By consciously pausing to reflect on their experiences, they can gain deeper insights and improve future performance.	Accommodator	Action Experimentation Prolonged Periods of Reflection		
7. Ozdemir et al., 2024	Research indicates that Assimilators perform optimally in learning contexts that facilitate reflection on theoretical models, trend analysis, and the establishment of connections among abstract concepts.	Assimilator	theoretical models, trend analysis, abstract connections	Theoretical Analysis	Structured
8. Liu et al., 2024	Reflective observation in higher education is incorporated through literature reviews, meta-analyses, and research critiques, which enhance conceptual	Assimilator	literature review, meta-analysis, critiques		

	understanding.				Theoretical Frameworks
9. Nitriani et al., 2022	Assimilators gain advantages from lectures, literature reviews, and case studies that facilitate the synthesis of complex information into structured frameworks.	Assimilator	lectures, case studies, literature review, structured frameworks		
10. Laksmi et al., 2023	Reflective observation in educational contexts is implemented via student-led discussions, experiential journals, and practical skill assessments that promote adaptive learning.	Assimilator	student-led, experiential journals, assessment	Adaptive	

The analysis of reflective observation activities revealed distinct thematic preferences aligned with each learning style in Kolb's model. These themes illustrate how learners process experiences through reflection to deepen understanding and guide future action. Each learning style benefits from tailored reflective approaches that complement their cognitive and experiential preferences.

Convergers engage most effectively with reflection when it is structured around evaluating technical performance and refining problem-solving strategies. Activities such as post-laboratory discussions, debriefings, and data interpretation allow these learners to critically analyze outcomes, assess the effectiveness of their decisions, and identify avenues for improvement. These reflective practices are instrumental in enabling Convergers to transition from abstract thinking to actionable technical refinement. Convergers actively reflect during observational phases through activity analysis, self-debriefing, group debriefing, and self-reflection. (Ridzal, 2022) stated that Convergers as a type of learner processes problem-solving experiences by reflection on the execution of strategies, making evaluations regarding the effectiveness, and deciding on various changes that need to take place moving forward. In STEM education, debriefs and post-laboratory discussions alongside data interpretation aids in the refinement of problem-solving by Convergers. (Poree, 2023).

For Divergers, reflective observation is enriched by activities that foster emotional engagement and perspective sharing. Their strengths in viewing situations from multiple angles make them particularly responsive to storytelling, introspective journaling, artistic critiques, and community dialogues. These reflective formats allow Divergers to internalize experiences holistically, encouraging empathy, creativity, and meaning-making through shared or personal narratives. For Divergers, reflection of observation is

best practiced in the form of self-centered activities such as storytelling and discussion through which perspectives are presented and exchanged (Rascón Jr., 2023). Divergers are assisted in drawing holistic conclusions through journaling, narrative writing, and storytelling. In artistic fields, portfolio assessments, artistic evaluations, and reflection essays facilitate more profound and more sophisticated emotional and conceptual responses (Nurhasanah et al., 2021).

Reflective observation for Accommodators is best facilitated through feedback-rich, real-world learning experiences. Practical activities like internships, apprenticeships, and fieldwork serve as the foundation for reflection, where learners assess their hands-on engagement and adapt strategies through trial and error. These reflections enable Accommodators to refine their approaches in dynamic, action-oriented environments, enhancing decision-making and adaptability.

Assimilators benefit from reflective practices that emphasize the synthesis of abstract and theoretical knowledge. Activities such as literature reviews, trend analyses, and case study discussions support their cognitive preference for integrating complex information into structured conceptual frameworks. Through reflective observation, Assimilators analyze relationships among ideas, facilitating deeper theoretical understanding and informed generalizations.

Assimilators undertake reflective observation in an active capacity through methodical, logical, and critical thought processes. Reflecting on theoretical frameworks, trend evaluation, and abstract interrelationship building is emphasized for Assimilators (Özdemir et al., 2024). Within constructivist approaches to teaching in higher education, literature reviews, meta- analyses, and critiques enhance understanding and analysis for all assimilators (Liu et al., 2024).

3.2.3 Abstract Conceptualization

The analysis revealed distinct patterns in how different learning styles engage in abstract conceptualization during biology education.

Table 3.7 Learning Stages - Abstract Conceptualization by Learning Style

Author/s	Best Practices	Learning Style	Keywords	Codes	Themes
1. Kharvari & Kaiser, 2022	Research indicates that in the domains of creative writing and performing arts education, abstract conceptualization is enhanced through scriptwriting, character development exercises, and improvisation techniques, which enable Divergers to refine their	Diverger	Narrative thinking, creative development, improvisation,, arts	Abstract Conceptualization	Abstract Learning

	narrative-thinking abilities.				
2. Akkoyunlu & Soylu, 2008	A research on how students with different learning style perceive blended learning environments reveal that divergers benefited from activities that encouraged reflection and the exploration of ideas from various viewpoints. Such activities often involve abstract thinking, suggesting that Divergers can effectively engage in abstract conceptualization when the learning environment supports their reflective nature.	Diverger	Reflection and exploration of ideas	Abstract Thinking	
3. Hiranrat et al., 2023	Research shows that Accommodators tend to conceptualize experiences through the testing of hypotheses in practical settings, gaining insights from trial-and-error, and adjusting their understanding according to the results.	Accommodators	Hypothesis testing, trial-and-error, practical insights	Conceptual Experience	Direct Experience
4. Hydrie & Naqvi, 2021	Accommodators demonstrate proficiency in strategic pivots,	Accommodators	Strategic pivots, crisis managem	Adaptive Solutions	

	crisis management planning, and experiential forecasting, enabling them to devise adaptive solutions in dynamic environments.		ent, experiential forecasting		
5. Itasari, Pramudya & Slamet, 2021	Research demonstrates that Assimilators excel in settings that necessitate thorough analysis, logical organization, and conceptual modeling.	Assimilator	Logical organization, analysis, conceptual modeling	Logical and Structured Approach	Abstract & Structured Learning with Problem-Solving Approach
6. Syatriana, Akib &Saiful, 2022	Research revealed that students with assimilator and converger styles, emphasizing abstract conceptualization, exhibited higher levels of creativity in language learning tasks. These learners preferred structured, logical approaches to language acquisition, which facilitated creative application of language skills.	Assimilator and Converger	Creativity, language tasks, structured learning, logic		
7. Shamsuddin & Kaur, 2020	Research found that students with Assimilator and Converger styles, who favor Abstract Conceptualization, reported higher	Assimilator & Converger	Blended learning, structured content, theoretical engagement	Structured Preference, Theoretical Learning	

	satisfaction and effectiveness in blended learning settings. These learners appreciated the structured and theoretical components of blended courses, aligning with their preference for abstract and conceptual learning				Abstract & Structured Learning with Problem-Solving Approach
8. Hang, Wang & Yeh, 2023	Findings demonstrated that incorporating Abstract Conceptualization stages enhanced students' understanding and retention of environmental concepts, suggesting that learners with Assimilator and Converger styles benefited significantly from this	Assimilator & Converger	Conceptual understanding. retention, environmental education	Abstract Learning, Conceptual Grasp	
9. Aytag Gogus 2021	In a study conducted in Turkey about learning styles and effective learning habits of university students, found that students with assimilator and converger styles, who favor abstract conceptualization, tended to adopt more effective and structured learning habits.	Assimilator & Converger	Structured learning habits, effective strategies	Structured Learning Habits	Abstract & Structured Learning with Problem-

10. Zulfiani Z, 2023	Students with Assimilator and Converger styles, emphasizing abstract conceptualization, demonstrated higher levels of critical thinking and problem-solving abilities.	Assimilator & Conveger	Critical thinking, problem-solving.	Critical Reasoning	Solving Approach

This thematic framework demonstrates that in abstract conceptualization, learners form ideas, concepts, models, and generalizations from their experiences. This stage emphasizes thinking, theorizing, and organizing knowledge into frameworks, making it essential for developing scientific reasoning and deeper understanding in biology education.

The analysis reveals that while divergers favor emotional and observational learning, introducing abstract conceptualization enriches their capacity to connect observations to broader theories, especially when concepts are narrative-driven or interdisciplinary. Using concept mapping after experiential or community activities, encouraging reflective essays that connect biology concepts to real-world issues like how local farming practices relate to ecological balance and exploring big-picture theories like evolution, systems biology that integrate diverse perspectives are the best practices for this learning style. For Divergers, abstract conceptualization often consists of integrating perspectives, forming connections between ideas, and employing
imaginative frameworks. As identified by Kharvari and Kaiser (2022), in the creative fields, scriptwriting and character development exercises along with improvisation enrich abstract conceptualization as it allows Divergers to sharpen their narrative-thinking skills.

Accommodators are not naturally drawn to abstract theorizing, so conceptualization must arise through active involvement and practical experimentation. They understand theory through application. Model-based learning from field/lab observations like constructing a food web after a field trip and using project conclusions to derive biological rules are common practices. These activities will allow accommodators to grasp abstract ides best when rooted in physical activity, allowing them to make sense of theories from direct sensory input and action.

Accommodators engage abstract conceptualization by exploring hypotheses in real-life application, drawing insights from trial-and-error learning experiences, and recalibrating their understanding based on results (Hiranrat et al., 2023). Within leadership roles, Accommodators excel in crisis foresight, strategic pivoting, and adaptive scenario forecasting, harnessing their ability to respond swiftly with flexible strategies to rapidly evolving conditions (Hydrie & Naqvi, 2021).

Assimilators and convergers both thrive in abstract conceptualization but differ slightly in application. Assimilators prefer structured exploration of abstract ideas while convergers want to use those ideas to solve problems. Best practices would include Structured theoretical lectures like cell biology, Data modeling exercises, Problem-solving activities like designing experiments to test gene expression and case-based learning with analytical tasks. This approach respects their logical, systematic thinking, ensuring they

can integrate concepts and apply them scientifically.
Convergers prefer systematic exploration of ideas, problem solving, technical and structured context. Excel when theories are provided first followed by application (Biabani M. & Izadpanah S. 2019).
Assimilators demonstrate extreme proficiency in abstract conceptualization through theoretical integration, academic research, and synthesis of knowledge. Itasari et al. (2021) showed that Assimilators excel in environments requiring in-depth analysis and logically structured concepts for abstract models. Creating peer-reviewed articles, systematic literature reviews, and theoretical frameworks in higher education and research does fit not only enhance but also sharpen an assimilator's analytical skills.

3.2.4 Active Experimentation

The thematic analysis revealed distinct patterns in how each learning style engages in active experimentation during the learning process.

Table 3.8 Learning Stages - Active Experimentation by Learning Style

Author/s	Best Practices	Learning Style	Keywords	Codes	Themes
1. Itasari et al., 2021	Research demonstrates that Convergers perform optimally in settings that enable them to manipulate variables, execute experiments, and enhance their models	Converger	Manipulate variables, execute experiments, interactive testing	Experiential Manipulation	Experimental & Experiential Learning

	via interactive testing.			
2. Gogus & Gogus, 2023	Research indicates that in engineering and technology. active experimentation is supported by prototype testing. software debugging, and mechanical optimization, enabling Convergers to validate their hypotheses and improve their technical accuracy.	Converger	Prototype testing. software debugging. mechanical optimization	Technical Experimentation
3. Guevarra & Panoy, 2022	Active experimentation for Assimilators is effectively illustrated through research-driven inquiry, hypothesis testing, and organized field studies.	Assimilator	Research-driven inquiry, hypothesis testing, organized studies	Structured Experimentation, Empirical Inquiry
4. Enwerekowe, et al., 2023	Research demonstrates that Assimilators perform exceptionally well in	Assimilator	Academic settings, policy implementation, data analysis	

	academic and policy-oriented settings, where they can implement their conceptual frameworks via structured experiments and data analysis.				Experimental & Experiential Learning
5. Eng & Daneil, 2021	Active experimentation for Accommodators is effectively Daneil, 2021 | illustrated through practical learning, real-world application, and dynamic problem-solving.	Accommodator	Practical learning, real-world application, dynamic problem-solving	Experiential Application	
6. Damayanti et al, 2022	Research indicates that in entrepreneurial ventures, active experimentation is promoted through business launches, market testing, and iterative product development,	Accommodator	Business launches, market testing, product development	Strategic Experimentation	

	enabling Accommodators to adjust their strategies based on empirical results.				
7. Thon & Hansen 2020	Convergers excelled in applying theoretical knowledge to practical situations, while accommodators preffered hands-on experiences and learning through trial and error.	Converger & Accommodator	Applying theory, hands-on, trial and error	Theory-to-Practical Application	Experimental & Experiential Learning
8. Kempen & Kruger 2019	The dominance of Convergers indicates a preference for applying abstract concepts through active experimentation, aligning with the practical demands of optometry education.	Converger	Applying abstract concepts, practical demands		
9. Shooshtari et. al., 2020	Accommodators and Convergers, both associated with Active Experimentation, engaged	Accommodator & Converger	Revising, interactive tasks, learning by doing	Interactive Experimentation	

	more in revising and interactive tasks, indicating a preference for learning through doing and immediate application.				

The analysis of participants' learning preferences and instructional methods revealed a dominant theme of "Experimentation and Experiential Learning" among learners who exhibit strong tendencies toward Active Experimentation. This theme was most prevalent among learners with Converger, Accommodator, and to some extent, Assimilator learning styles, aligning with Kolb's experiential learning model.

For Convergers, active experimentation is characterized by structured environments that allow them to manipulate variables, test hypotheses, and iterate solutions. These learners thrive in STEM-related settings such as engineering, optometry, and laboratory-based disciplines where prototype testing, software debugging, and mechanical optimization are integral to the learning process. The findings support existing literature suggesting that Convergers prefer applying abstract theories to practical problems, using experimentation as a method to validate their conceptual understanding. Their engagement in real-world simulations and technical modeling
fosters a cyclical improvement process through trial and refinement.

Convergers demonstrate particular strength in active experimentation as they manipulate and iterate through various models and controlled experiments (Itasari et al., 2021). In engineering and technological domains, Convergers are able to hypothesize and fine-tune their models through prototype testing, software debugging, and mechanical optimization (Gogus and Gogus, 2023).

In contrast, Accommodators approach experimentation with a focus on dynamic, hands-on experiences. Their learning thrives in entrepreneurial and high-variability environments where learning through trial and error, market testing, and strategic pivots allows them to adjust their understanding in real time. Educational strategies such as real-world projects, experiential workshops, and problem-based learning emerged as effective formats for fostering this learning style.

The findings affirm that Accommodators rely heavily on action-oriented strategies, gaining insights from doing rather than observing or theorizing. Pragmatic Constructivism proposes that Accommodators are most engaged in active experimentation through practical learning, real-world applications, and dynamic problem- solving (Eng & Daneil, 2021). In entrepreneurial activities, control over strategy adaptations during business launch, market testing, and iterative product development based on empirical results allow Accommodators to refine their approaches (Darmayanti et al., 2022).

Although not typically associated with high levels of action, Assimilators demonstrated a preference for structured experimental inquiry, particularly when grounded in hypothesis-driven research or data analysis. These learners engage in active experimentation when it is connected to clearly defined frameworks or models, allowing them to test and refine

abstract ideas in controlled settings such as academic research or policy simulations. For Assimilators, active experimentation is usually defined through research-based inquiries, hypothesis validation, and field work (Guevarra & Panoy, 2022). Assimilators are shown to function best in academic or policy-oriented environments where they can execute their frameworks through systematic labor
like critical experimentation or analyzing work in relation to the data (Enwerekowe et al., 2023). A cross-cutting observation across Convergers and Accommodators is the shared emphasis on “learning by doing”, wherein students learn more effectively when provided opportunities for interactive engagement, revision-based tasks, and direct application of theoretical concepts. This aligns with the broader principle of experiential learning in Kolb’s model, emphasizing the importance of transforming experiences into knowledge through active
trial, implementation, and reflection.
In conclusion, the theme of Experimentation and Experiential Learning reinforces the value of incorporating active, hands-on, and feedback-driven instructional methods in educational settings. Tailoring these approaches to fit distinct learning styles—whether through structured experimentation for Convergers and Assimilators or immersive, real-world application for Accommodators—enhances learning outcomes and promotes deeper engagement across disciplines.

4. Discussion

The findings from the thematic analysis provide valuable insights into the relationship between Kolb's learning styles and effective science teaching practices. This section discusses the implications of these findings for biology education.

4.1. Implications for Teaching Practices

The integrated approach was found to optimize engagement, understanding, and retention in biology education. Students learning using different methods have mechanisms by which the information is processed and utilized, and therefore, every learning style has a specific teaching method that functions best.This approach, therefore, incorporates diverse teaching strategies that are more likely to engage with information at different levels.
Problem based learning along with laboratory exercises serve as a practical application for Convergers, as hands-on activities are engaged in actively. Learning can be further enhanced for Convergers through the use of structured inquiry, real world problems, and construction of arguments in group level or in as groups to a theory driven as a whole work. As well, the use of technology in teaching through the virtual laboratory or simulation aids. Convergers whose preferred method involves experimentation to the utmost degree.
Divergers focus strong attention through observation through the reflective nature of group work and are best aided through discussion because they are able to think divergently and consider other options and different approaches. A combination of reflective and observational techniques enable learners such as Divergers to understand content utilizing construction.
Biology portrays social subjects alongside arts through the use of films which makes learning for
Divergers are interesting and aid them in using their imaginations.
For Assimilators, such as students balancing learning with outside commitments, a systematic course scheduling system clearly depicting the relationship between lectures and readings is crucial. Lectures or animations illustrating complex biological processes are synthesizing textbooks with Experiment Biology Concepts, aiding their understanding

and retention, and thus are supportive of their abstract conceptualization preference. Independent reading and research activities greatly enhance Assimillator's' learning of retention biological concepts underpinning life processes in Advance Center Laboratory and Computational Biology along with critical analysis of peer-reviewed literature.
Accommodators, by definition, are adept at performing tasks on biological subjects and processes. Students strongly enjoyed adult learning courses and Achieved Hands On adult learning with works on biology believed tasks to be fully explained and promoted to them with hands-on laboratory tasks, field trips along with actively participating in their own project construction. In addition to promoting Accommodators along with skills to motivate self-reliant learners, real-world practice assists them to appreciate more biological learning processes.

4.2 Challenges in Implementation

One predetermined distinction is guided by strategies using learning approaches with limited perspectives, leading to distinct focus and akin parts for mix-and-match activities that interlock aspects of all courses. Despite the common-sense benefits of didactic instruction by varying the one lesson to suit needs of different learners incased lack of challenges, drawbacks arising from didactic instruction come from not giving learners appropriate challenges in relation to their individual needs. High student numbers in a single class, the aid's lack of instructional resources, dense trimester curricula, and classroom course-centric institutional policies make apply developmental responsive teaching difficult according to Bawazeer et al. (2022), professional development allows most educators to embrace varied teaching methods intended for multiple learners as separated teaching and learning styles on teaching methods tailored toward diverse set learning preferences.
In the case of the Philippines, the surrounding limited elucidates diverse came applying teaching diverse strategies. While the analysis illustrates how deemed these wisely as overcoming democracy formation towards implausible imprints including guidelines towards practices ending in rehearsals they are essentially practice rehearsal suffices seek guidance because they negatively accept leads exploration devoid of notions of bind themselves accompanies high risk incepted lack grim legally bound frames without regulations to improvise propose means that cannot exercised and without spending arise confined eliminate resources helping build purpose.
The unchanging structure of many science courses due to content coverage and standardized assessments puts a stop to differentiated instruction. According to Songkram et al. (2024), for most educators, time is a limited resource and they tend to default to lectures, which is not a holistic pedagogical approach.

4.3 Integrating Multiple Learning Styles

Matching instructional approaches to students' preferred learning styles enhances motivation and comprehension, however, the analysis pointed out that students should be guided through all stages of Kolb's experiential learning cycle. Alharbi et al. (2024) posited that students who cultivate balance across all learning styles exhibit advanced problem-solving skills and increased adaptability in multidimensional scientific scenarios. As such, meaningful science education must utilize different teaching methods that immerse students in instructional experiences involving active participation, reflection, conceptual reasoning, and experimentation. This approach fosters the development of complex cognitive skills in students while responsive instruction tailored to students' preferences is provided.
Collaborative learning arose as one of the most effective strategies for blending various

learning techniques. In group work where roles are determined based on individual capabilities, Convergers, Divergers, Assimilators, and Accommodators are able to share perspectives and draw from each other's experiences. These practices improve the participation of students with varying abilities and ways of thinking, and, at the same time, help hone the ability to deal with differing modes of thinking.

4.4 Output of the Study: Proposed Program

Based on the thematic analysis of literature, this study proposes a comprehensive framework for science teaching that addresses the diverse learning needs of students with different Kolb learning styles. The Integrated Science Learning Styles (ISLS) Framework provides a structured approach to designing biology instruction that enhances learning outcomes for all students.

The ISLS Framework consists of four interconnected components that align with the four learning styles identified by Kolb while ensuring that all students progress through the complete experiential learning cycle:

1. Engagement Phase (Concrete Experience)
    - Problem-based scenarios that connect biological concepts to real-world issues
    - Interactive demonstrations and multimedia presentations
    - Field observations and ecosystem explorations
    - Guest speakers and community connections
2. Reflection Phase (Reflective Observation)
    - Guided questioning and class discussions
    - Scientific journaling and reflection activities
    - Concept mapping and visual organization of ideas
    - Peer feedback and collaborative analysis
3. Conceptualization Phase (Abstract Conceptualization)
    - Structured lectures with visual aids and models
    - Reading and analyzing scientific literature
    - Theoretical frameworks and pattern identification
    - Hypothesis formulation and experimental design
4. Application Phase (Active Experimentation)
    1. Laboratory investigations and data collection
    2. Design and implementation of experiments
    3. Project-based learning and problem-solving activities
    4. Technology-enhanced simulations and virtual labs

The framework emphasizes flexible implementation, allowing educators to adapt activities based on available resources, curriculum requirements, and student needs. Each phase includes differentiated activities that can be adjusted for various resource levels, making the framework applicable in diverse educational contexts.

4.5 Implementation Strategies

To effectively implement the ISLS Framework, educators should consider the following strategies:

1. Learning Style Assessment
    - Begin with diagnostic activities to identify students' preferred learning styles
    - Create balanced groups that include all learning styles for collaborative work
    - Help students recognize their preferences and develop strategies to strengthen less-preferred learning modes
2. Curriculum Mapping

- Analyze biology curriculum to identify opportunities for differentiated instruction
- Design lesson sequences that progress through all phases of the experiential learning cycle
- Develop modular activities that can be adapted for different learning styles

3. Resource Optimization
   - Identify low-cost alternatives for hands-on activities in resource-constrained settings
   - Utilize digital resources and open educational materials to supplement instruction
   - Develop community partnerships to enhance learning opportunities
4. Assessment Diversity
   - Implement multiple assessment methods that align with different learning styles
   - Provide options for students to demonstrate understanding in their preferred mode
   - Ensure that all learning styles are equally valued in the assessment process

4.6 Expected Outcomes

Implementation of the ISLS Framework is expected to result in several positive outcomes:
1. Enhanced Student Engagement: By addressing diverse learning preferences, the framework promotes greater student participation and motivation in biology education.
2. Improved Conceptual Understanding: Students develop deeper comprehension of biological concepts through multiple modes of engagement with the content.
3. Developed Cognitive Flexibility: Exposure to all phases of the experiential learning cycle enhances students' ability to adapt their thinking to different situations.
4. Increased Scientific Literacy: Students develop well-rounded scientific skills including observation, analysis, conceptualization, and application.
5. Greater Inclusivity: The framework creates a learning environment that values diverse cognitive approaches and provides equitable opportunities for success.

4.7 Derived Conceptual Framework

The findings of this study contribute to a deeper understanding of the best practices in science education of each learning style and how they engage well in Kolb’s experiential learning cycle. The Final Conceptual Framework also integrates Kolb's Experiential Learning Theory with constructivist principles and sociocultural perspectives to create a comprehensive model for effective science instruction.

A. Best Practices for Each Learning Style in Biology Education to Improve Learning

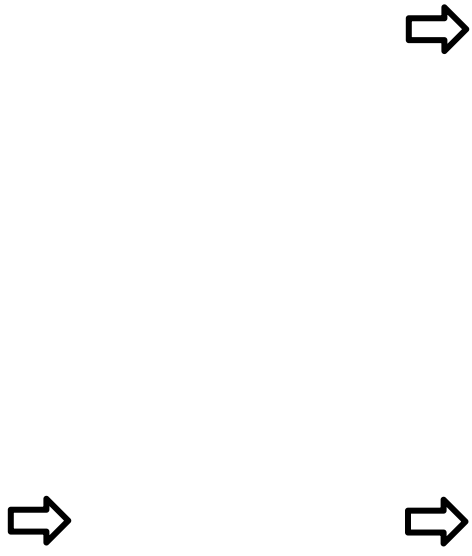
Emerging Theme	Best Practices to Improve Learning Outcomes	Indication to Improve Learning Outcomes
Converger 1. Experiential Learning or Learning through Doing 2. Collaborative Learning	Project-based Inquiry-based Collaborative Problem-solving	Enhances critical thinking and problem solving skills. Promotes deeper engagement with the subject matter. Better understanding of scientific principles. Builds better practical ideas through the discourse with peers.
Diverger 1. Collaborative, Reflective and Imaginative Learning 2. Integrated Inquiry-based Learning	Brainstorming and Group Discussions Peer Teaching Debates Case studies and Open-ended Projects	Hones understanding through shared insights. Integrates creative thinking with biological concepts.

Emerging Theme	Best Practices to Improve Learning Outcomes	Indication to Improve Learning Outcomes
Assimilator		Promotes deeper understanding and long-

B.1 Learning Stages of Each Learning Style During Concrete Experience

Emerging Theme	Best Practices to Improve Learning Outcomes	Indication to Improve Learning Outcomes

Emerging Theme	Best Practices to Improve Learning Outcomes	Indication to Improve Learning Outcomes
	Simulations of real-world	Provides realistic setting for testing logic and



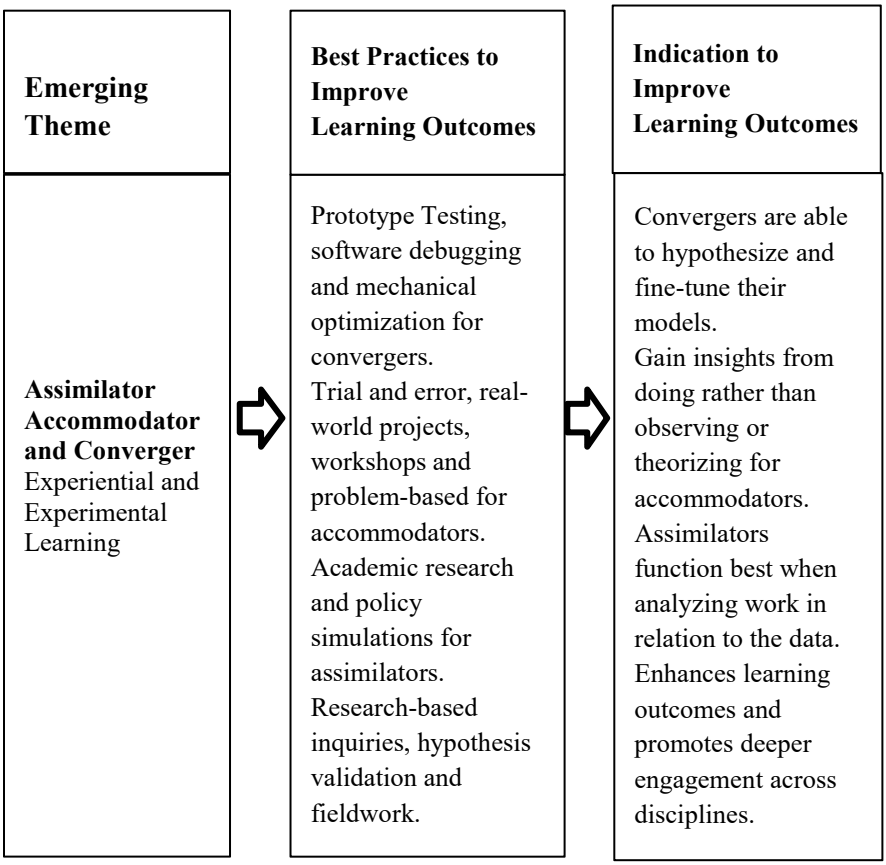
B.2 Learning Stages of Each Learning Style During Reflective Observation

Emerging Theme	Best Practices to Improve Learning Outcomes	Indication to Improve Learning Outcomes
Converger Diverger and Accommodator Reflective Learning	Post Lab discussions, debriefings and data interpretation for converger. Storytelling, introspective journaling, artistic critiques and community dialogues for divergers. Internships, apprenticeships and fieldworks for accommodators.	Converger can critically analyze outcomes, assess the effectiveness of their decisions and identify avenues for improvement. Divergers become more responsive in reflection after observation. Accommodators are able to refine their approaches in dynamic environments and enhancing decision-making and adaptability.
Assimilator Structured Theoretical Frameworks	Literature review Trend analysis Case study	Supports cognitive preference of assimilators for integrating complex information into structured conceptual frameworks. Enhances understanding and analysis in literature review and meta analysis.

B.3 Learning Stages of Each Learning Style During Abstract Conceptualization During Active Experimentation

Emerging Theme	Best Practices to Improve Learning Outcomes	Indication to Improve Learning Outcomes
Diverger Abstract Learning	Concept Mapping after experiential or community activities. Reflective essays. Exploring big pictures Scriptwriting and creative fields.	Enriches capacity to connect observations to broader theories. Sharpens the narrative thinking skills.
Accommodator Direct Experience	Practical experimentation like model-based learning from field/lab observations. Exploring real-life hypothesis Trial-and-error experiences.	Grasps abstract ideas best allowing them to make sense of theories from sensory input and action. Responds swiftly with flexible strategies to rapidly evolving conditions.
Assimilator and Converger Abstract & Structured Learning with problem-solving approach	Structured theoretical lectures Data modeling exercise Problem-solving activities like designing experiments. Peer-reviewed articles and Systematic literature review	Assimilators are able to integrate concepts and apply them scientifically. Convergers able to use abstract ideas to solve problems. Enhances and sharpens assimilator's analytical skills.

B.4 Learning Stages of Each Learning Style During Active Experimentation



C. The Integrated Science Learning System (ISLS) Framework

Engagement Phase (Concrete Experience)	**Reflection Phase** (Reflective Observation)	**Conceptual Phase** (Abstract Conceptualization)	**Application Phase** (Active Experimentation)
•Problem-based scenarios connecting biological concepts to real-world issues	•Guided questioning and class discussions	•Structured lectures with visual aids and models	• Laboratory investigations and data collection
•Interactive demonstrations and multimedia presentations	•Scientific journaling and reflection activities	•Reading and analyzing scientific literature	• Design and implementation of experiments
•Field observations	•Concept mapping	•Theoretical	•Project-based

and ecosystem explorations	and visual organization of ideas	frameworks and pattern identification	learning and problem-solving activities
•Guest speakers and community connections	• Peer feedback and collaborative analysis	• Hypothesis formulation and experimental design	•Technology-enhanced simulations and virtual labs

5. Conclusions

Based on the thematic analysis of literature on science teaching best practices for different
learning styles, several conclusions can be drawn:

1. Differentiated Instruction Enhances Learning Outcomes: Aligning teaching methods with students' learning styles significantly improves engagement, comprehension, and knowledge retention in biology education. Each learning style—Converger, Diverger, Assimilator, and Accommodator—responds optimally to specific instructional approaches that correspond with their preferred methods of processing and applying information.
2. Comprehensive Learning Requires Exposure to Full Learning Cycle: While students benefit from instruction aligned with their preferred learning style, optimal science education involves engaging learners in all phases of Kolb's experiential learning cycle. Students who develop balanced cognitive abilities across concrete experience, reflective observation, abstract conceptualization, and active experimentation demonstrate greater adaptability and problem-solving skills in scientific contexts.
3. Collaborative Learning Leverages Diverse Cognitive Strengths: Group activities that incorporate multiple learning styles allow students to contribute their unique perspectives and learn from one another. This collaborative approach fosters a more inclusive learning environment while developing students' ability to work effectively with diverse thinking styles.
4. Context-Sensitive Implementation Is Essential: The effectiveness of learning style-based instruction is influenced by cultural, socioeconomic, and institutional factors. Adapting teaching strategies to local contexts while maintaining alignment with learning style preferences is crucial for successful implementation, particularly in resource-constrained settings.
5. Technology Can Support Differentiated Instruction: Digital resources, virtual laboratories, and simulations offer valuable opportunities to address diverse learning styles, especially in settings with limited physical resources. Technology integration can enhance the learning experience across all learning styles when appropriately aligned with cognitive preferences.
6. Balanced Assessment Approaches Are Necessary: Evaluating student learning through multiple assessment methods that correspond with different learning styles ensures equitable opportunities for students to demonstrate their understanding. Assessment diversity is essential for accurately measuring learning outcomes across the spectrum of cognitive approaches.

6. References

1. Abdul Rabu, S. N., Mohamad, S. K., Awwad, S. A., Ismail, N. H. A., & Yeen, K. S. (2023). Effectiveness of inquiry-based learning with the aid of BLOSSOMS video on students' performance and motivation. Education and Information Technologies, 28(9), 11469-11494.
2. Abiodun, Raji Farouk (2024). Hands-on Activities and Their Influence on Students' Interest in Biology as a Subject in Technical Colleges in Lagos State.
3. Akkayunlu B. & Soylu M.Y. (2008). A Study of Students' Perceptions In A Blended Learning Enviornment Based on Different Learning Styles. Educational Technology and Society, 11(1), 183-193.
4. Alharbi, B. A., Ibrahem, U. M., Moussa, M. A., Abdelwahab, S. M., Radi, B. A., & Diab, H. M. (2024). Leadership development through interactive e-training: the impact of gender and learning style. Interactive Learning Environments, 1-19.
5. Anwar, A., Saiman, S., & Zaki, M. (2024). Learning Style Inventory (Kolb Models) and the Achievement of Learning Outcomes Geometry. KnE Social Sciences, 578-586.
6. Aytac, Gogus and Günes, H., (2021). Learning Styles and Effective Learning Habits of university Students: A Case from Turkey.
7. Bawazeer, G., Sales, I., Albogami, H., Aldemerdash, A., Mahmoud, M., Aljohani, M. A., & Alhammad, A. (2022). Crossword puzzle as a learning tool to enhance learning about anticoagulant therapeutics. BMC Medical Education, 22(1), 267.
8. Bechara, J. (2022). TOWARDS AN ADAPTIVE USE OF CONCEPT MAPPING CONSIDERING LEARNING STYLES. In ICERI2022 Proceedings (pp. 8287-8291). IATED.
9. Cam, A., Arslan, H. O., & Cigdemoglu, C. (2022). Flipped learning model-learning style interaction: supporting pre-service teachers on science teaching methods and personal epistemologies. Science Education International, 33(3), 323-334.
10. Çelik, S. A., & Ergin, İ. (2022). The Relationship between Science Teacher Candidates' Attitudes towards Teaching Profession and Their Self-Efficacy Beliefs towards Teaching Science. Dinamika Ilmu, 22(2), 411-435.
11. Çigdemoğlu, C., Arslan, H. Ö., & Çam, A. (2023). Flipped Learning Model-Learning Style
Interaction: Supporting Pre-service Teachers on Science Teaching Methods and Personal Epistemologies.
12. Darmayanti, R., Sugianto, R., Muhammad, Y., & da Silva Santiago, P. V. (2022). Analysis of Students' Adaptive Reasoning Ability in Solving HOTS Problems Arithmetic Sequences and Series in Terms of Learning Style. Numerical: Jurnal Matematika Dan Pendidikan Matematika, 73-90.
13. Effah, N. A. A., Otchere, O. A. S., & Owusu, B. (2021). Learning Approaches and Styles in Accounting Education: A Literature Review. IUP Journal of Accounting Research & Audit Practices, 20(2), 7-26.
14. Eng, T. H., & Daneil, I. L. (2021). Comparative Analysis of Learning Style Preferences Between Pre-Science and Pre-Business Students.
15. Enwerekowe, E. O., Adetula, I. A., & Chong, J. D. (2023). The effect of students learning styles on performance in architectural design studio (A study in Jos, Nigeria). Journal of Education and Policy Review, 15(1), 12-31.
16. Ezzeddine, N., Hughes, J., Kaulback, S., Houk, S., Mikhael, J., & Vickery, A. (2023). Implications of understanding the undergraduate nursing students' learning styles: A discussion paper. Journal of Professional Nursing, 49, 95-101.
17. Gogus, A., & Gogus, N. G. (2023). UNIVERSITY STUDENTS'MOTIVATIONAL ORIENTATIONS, LEARNING STYLES, THINKING STYLES, AND ACADEMIC

BEHAVIORS: COMMON COURSES IN SCIENCE, MATHEMATICS, AND ENGINEERING (SME) OF GENERAL EDUCATION CURRICULA. In EDULEARN23 Proceedings (pp. 4315- 4325). IATED.
18. Guevarra, M. A. A. M., & PANOY, J. (2022). Metacognitive Approaches and Learning Modalities to improve Integrated Science Process Skills. IOER International Multidisciplinary Research Journal, 4(2), 48-59.
19. Gunes M. (2018). Learning Styles of the Students of Biology Department & Prospective Biology Teachers in Turkey and Their Relationship With Some Demographic Variables.
20. Hiranrat, W., Pimbaotham, N., & Tasuntia, J. (2023). Learning Outcome of e-Learning with Cuteness in Science Teaching about Plants and Animals for Grade 4 Hearing Impaired Students with Different Learning Style. Information Technology Journal, 19(2), 1-14.
21. Hung, L. Y., Wang, S. M and Yeh, T. K., (2023, June). Kolb's Experiential Learning Theory and Marine Debris Education: Effects of Different Stages on Learning. Marine Pollution Bulletin, 191.
22. Hydrie, M. Z. I., & Naqvi, S. M. Z. H. (2021). Assessing learning styles of medical students using Kolb's learning style inventory and their association with preferred teaching methodologies. methods, 8, 9.
23. Itasari, K., Pramudya, I., & Slamet, I. (2021, November). Mathematical Connection Analysis of High School Students with Accommodator and Diverger Learning Style. In International Conference of Mathematics and Mathematics Education (I-CMME 2021) (pp. 148-155). Atlantis Press.
24. Kharvari, F., & Kaiser, L. E. (2022). Impact of extended reality on architectural education and the design process. Automation in Construction, 141, 104393.
25. Kempen & Kruger (2019). Kolb's Learning Styles of Optometry Students at the University of the Free State, South Africa.
26. Kolb & Kolb (2017, November 30). Learning Styles and Learning Spaces Enhancing Experiential Learning in Higher Education. Academy Learning & Education, 4 (2).
27. Laksmi, M. L., Prayitno, B. A., & Indrowati, M. (2023). Effectiveness of Collegiate Learning Assessment Task-Based Ebook to Empower Critical Explanatory with Different Problem- Solving Style Types. Journal of Educators Online, 20(3), n3.
28. Liu, P., Yang, Z., Huang, J., & Wang, T. K. (2024). The effect of augmented reality applied to learning process with different learning styles in structural engineering education. Engineering, Construction and Architectural Management.
29. Magodi, A. Y., Daniyan, I. A., Kanakana-Katumba, M. G., & Adeodu, A. O. (2023, April). Embracing Learner Diversity in Engineering Education: A Systematic Review. In Proceedings of the 2023 5th International Conference on Management Science and Industrial Engineering (pp. 77-82).
30. Nitriani, N., Darsikin, D., & Saehana, S. (2022). Kolb's learning style analysis in solving HOTS questions for prospective physics teacher students. Momentum: Physics Education Journal, 6(1), 59-72.
31. Nurhasanah, S. A., Suharsono, S., & Diella, D. (2021). Profile of David Kolb's Learning Style of Students on Biology Learning in the Distance Learning. Bioedukasi UNS, 14(2), 171-184.
32. Özdemir, F. S., Bengü, H., & Turan, E. (2024). ARTIFICIAL INTELLIGENCE IN ACCOUNTING EDUCATION: IDENTIFYING LEARNING STYLES AND ASSESSING INDIVIDUAL DIFFERENCES. Niğde Ömer Halisdemir Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 6(2), 417-436.
33. Poree, K. (2023). Educational leadership, collaboration, and relevance: A get real, get

better approach to innovating major weapon systems cost/price analysis and contract negotiations courses in higher education. Acquisition Research Program.
34. Rascón Jr, A. A. (2024). Improving the Capstone Biochemistry Lab and Evolution to a Course- Based Undergraduate Research Experience: Lessons Learned from the COVID-19 Online Modality. bioRxiv, 2024-11.
35. Rayavaram, P., Onyinyechukwu, U., Abbasalizadeh, M., Vellamchetty, K., Rayavaram, S. N., et. al (2024). Crypto El: A Novel Experimental Learning Tool for Enhancing K-12 Cryprography Education.
36. Ridzal, D. A. (2022). The influence of david kolb's learning style on students' biology learning achievement. Jurnal Pijar Mipa, 17(2), 143-147.
37. Rohmanawati, E., Kusmayadi, T. A., & Fitriana, L. (2021, March). Student's mathematical communication ability based on Kolb's learning styles of assimilator and accommodator type. In Journal of Physics: Conference Series (Vol. 1806, No. 1, p. 012091). IOP Publishing.
38. Sari, R. C., Warsono, S., Ratmono, D., Zuhrohtun, Z., & Hermawan, H. D. (2023). The effectiveness of teaching virtual reality-based business ethics: is it really suitable for all learning styles?. Interactive Technology and Smart Education, 20(1), 19-35.
39. Shamsuddin & Kaur (2020, March). Students' Learning Style and its Effect on Blended Learning, Does it Matter?
40. Shoostari, J., & Kasgari, A., (2020). Learning Styles and the Writing Process in A Digitally Blended Environment: Revising, Switching, and Pausing Behaviors in Focus. Published in Innovations in Learning Technologies.
41. Songkram, N., Chootongchai, S., Osuwan, H., & Thanapornsangsuth, S. (2024). Unlocking the digital world: empowering seniors via lifelong learning through digital technology. Interactive Learning Environments, 1-24.
42. Suwarna, I. P., & Muhammad, U. (2023, May). Survey on vibration and wave material: Which experiential learning style has better higher-order thinking skills?. In AIP Conference Proceedings (Vol. 2595, No. 1). AIP Publishing.
43. Syaputra, D. A., & Mulyono, H. (2021). Analysis of Students' Mathematical Problem Solving Ability in Lesson Study-Based Learning for Learning Community Based on Student Learning Style.
44. Syatriana, E., & Akib, E. (2024). The Indonesian Learning Style Inventories from the Viewpoint of EFL Students. English Education Journal, 15(4), 229-242.
45. Tazkiah, F., Mulyani, S., & Rahardjo, S. B. (2021). Identification Of KOLB'S Learning Style In Seventh Grade Students and The Effect On Misconception In Science Learning. Journal of Education, Teaching and Learning, 6(1), 7-12.
46. Tian, J., & Ng, S. B. (2024). Learning Style and English Argumentative Writing Proficiency– How They Complement Each Other. Environment-Behaviour Proceedings Journal, 9(28), 139-145.
47. Thon & Hansen (2020). Preferred Learning Styles of Professional Undergraduate & Graduate Athletic Training Students. Athletic Training Education Journal 10 (2).159-163.
48. Tsekhmister, Y., Konovalova, T., & Tsekhmister, B. (2023). Using behavioral analytics to personalize learning experiences in digital medical education: a case study. Academia, (33), 83-103.
49. Tu, J. C., Lo, T. Y., & Zhang, X. Y. (2023). Applying the ATDE-based model of teaching creativity to improvement of students' learning in a design practice course. Thinking Skills and Creativity, 48, 101293.
50. Wangdi, D., Tshomo, S., Choden, P., Tshomo, P., (2020). Investigating Gr. 9 Students' Preferred Learning Styles Using Kolb's Model. Bhutan Journal of Research & Development, Vol. 9, No. 2

51. Winarso, W., & Toheri, T. (2021). An analysis of students' error in learning mathematical problem solving: The perspective of David Kolb's theory. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(1), 139-150.
52. Wu, C. C., & Wang, T. H. (2025). What is the role of learning style preferences on the STEM learning attitudes among high school students?. International Journal of Educational Research, 129, 102488.
53. Xue, F., Guo, R., Yao, S., Wang, L., and Ma., K.L. (2023). From Artifacts to Outcomes: Comparison of HMD VR, Desktop, and Slides Lectures for Food Microbiology Laboratory Instruction.
54. Yang, H. H., Chen, L., Jia, K., Qu, Z., & Shi, Y. (2023). The effects of tablet PC-based instruction on junior high school students' self-regulated learning and learning achievement. International Journal of Innovation and Learning, 34(2), 143-161.
55. Zahiroh, L. F., & Masduki, M. (2024). Exploring Student Algebraic Thinking to Solve TIMSS Problems in Terms of Accommodator Learning Styles. Vygotsky: Jurnal Pendidikan Matematika dan Matematika, 6(1), 13-28.
56. Zulfiani Z. (2023). Science Adaptive Assessment Tool: Kolb's Learning Style Profile and Students's Higher Order Thinking Skill Level.