

The Ferreira's Ecosystem for Teaching and Learning (FETL) Model

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ABSTRACT

This paper presents the Ferreira's Ecosystem for Teaching and Learning (FETL) Model; an effective, comprehensive, and theoretically designed framework to revolutionize lesson planning and delivery by integrating various pedagogical and andragogical best practices. Developed from a critical literature review, international teaching experiences, and subject matter expertise. The FETL Model considers five key drivers: External Environments, Student Profiles, Assessment Data, Curricula and Standards, and Internal Environments. Each influences the effectiveness and relevance of the teaching and learning process. The model underscores the importance of contextualizing lessons within current and past events to ensure that content resonates with students' diverse backgrounds, learning styles, and real-world experiences. It promotes equity in the classroom, ensuring that learning experiences are engaging, personalized, and inclusive for all students. It fosters critical thinking, creativity, and collaboration through immersive learning techniques, including artificial intelligence (AI).

1. Introduction and Purpose

The purpose of this paper is to present the Ferreira's Ecosystem for Teaching and Learning (FETL) Model as a revolutionary solution to the clarion call highlighted in literature for new and innovative teaching and learning frameworks to effectively cater to the changing learning needs, academic abilities, career interests, cultural and linguistic backgrounds of students in today's K-12 classrooms and higher education institutions. Further, the statistically significant results of an empirical study conducted in one secondary school (four mathematics classes) and two postsecondary institutions (four science classes) in Guyana on the FETL Model's effectiveness and applicability across content areas and grade levels are presented. The emergence of artificial intelligence (AI) in the education industry, rapidly changing diversity of students in schools, and the urgency to ensure that K-12 (nursery, primary, and secondary) students are college, career, and military ready (CCMR), and higher education graduates are globally competitive, competent workers, and environmentally oriented, demand innovative teaching and learning models. Before presenting a discussion on the FETL Model, which has the potential to reimagine and redefine lesson planning and lesson delivery, a rationale for this

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model is presented. There are several reasons why newer and more effective teaching and learning methods are needed in today's classrooms: (a) college, career, and military readiness; (b) teaching methods must evolve to align with changes in the education industry; (c) employing artificial intelligence in teaching and learning in K-12 education; (d) authentic and modern assessment methods; (e) innovative lesson planning and lesson delivery methods; and (f) factors that should be informing lesson planning and learning activities.

2. Review of Literature

2.1. Theoretical Frameworks

The proposed FETL Model is grounded in three theories: constructivism theory, Gagne's 9 events of learning, and formative assessment. There is no research to date that indicates the three theory-based lesson plan for enhancing the teaching and learning process (Iqbal et al., 2021). The constructivism theory postulates that active participation in the learning process increases learning (Iqbal et al., 2021). The constructivism theory assumes that students learn when they piece together new information with their existing knowledge. Constructivists are of the notion that students' learning is influenced by the context in which the concept is presented coupled with students' beliefs and attitudes (Bada & Olusegun, 2015). Constructivism is considered an important quality in contextual teaching and learning (Efgivia et al., 2021).

Gagne's 9 events of learning are required to foster learner attention by stimulating them to solve novel problems. The nine levels of learning include: (1) capturing attention; (2) disseminating learning objectives; (3) stimulating retention of prerequisite learning; (4) highlighting the stimulus material; (5) giving learning guidance; (6) presenting the performance; (7) giving feedback about performance correctness; (8) evaluating performance; and (9) developing memory (Iqbal et al., 2021). Gagne's 9 events of learning play a pivotal role in designing lesson plans and are used by a substantial number of teachers around the world (Iqbal et al., 2021). Gagne's internal factors impact students' academic performance and therefore must be included in the planning and instruction (Ngussa, 2014). Gagne's theory posits that various forms of learning exist which require varied instructional conditions to foster the different learning outcomes (Solanki, 2014).

Formative assessment is viewed as the most effective assessment methods compared to other forms of assessments because it provides for learner engagement, triangulation of different facts and findings, blended learning, reflective practices, self-assessment, established learning outcomes, and various feedback loops (Terblanche, 2017, as cited in Iqbal et al., 2021). There are two adjoining assessment goals of formative assessment: (1) assessment for learning; and (2) assessment as learning (Clark, 2012). Formative assessments which can be both formal and informal are designed to enhance student learning by providing information about performance (Yorke, 2003).

2.2. College, Careers, and Military Readiness (CCMR)

This section examines whether K-12 schools (nursery, primary, and secondary schools for some countries in the Caribbean and other continents) are adequately preparing high school graduates for college, careers, and military. In the United States (US), high school graduates from across the states are void of the knowledge and skills necessary for them to be successful in college and workforce (Carnevale et al., 2010; Loera et al., 2013, as cited in Fletcher et al., 2018). Haskins and Kemple (2009) stated that the principal reason for low-income and minority

students failing to enroll in and graduate from postsecondary institutions is that they are not adequately prepared for college success. College and career readiness is defined as graduating students that will satisfy college admission requirements without the requirement for remedial or developmental courses, and be successful in entry-level, credit-courses in certificate and bachelor's degree programs or career pathway training programs (Conley, 2012). Succi and Canovi (2020) found that 86% of research participants emphasized a growing need for soft skills over the last five to ten years and companies now prioritize soft skills as even more important than graduates. CCMR is a requirement for all high school graduates in the State of Texas.

The Texas College and Career Readiness School Models (CCRSM) provide opportunities for historically underserved and at-risk high school students to enroll in dual credit or dual enrollment college courses to develop technical skills, earn college degrees, and pursue high-demand career paths (Texas Education Agency [TEA], 2024). Furthermore, high school students can earn a maximum of 60 college credit hours, high school diplomas, industry certifications, and associate degrees through early college high schools (ECHS) and pathways in technology early college high schools (P-TECH) programs (TEA, 2024). The Division of College, Career, and Military Preparation (CCMP) mandates and works to ensure that high-quality pathways to career and college are made available to all Texas high school students (TEA, 2024).

2.3. Teaching Methods Must Evolve to Align with Changes in the Education Industry

Educator's ability to perform automatically links and reflects on student learning (Hattie, 2013, as cited in Kovacs, 2017). Teaching and learning strategies and models must evolve over time to align with the rapid changes (classroom diversity, curriculum, and policies) in the education industry. The lecture method of teaching has been criticized as being ineffective, archaic, and a passive form of learning (Estai & Bunt, 2016). Traditional educators take on the principal authority and responsibility in their classrooms because of the belief that they know their students' needs and the learning environment must stringently follow specified time and place (Austing et al., 2001, as cited in Khalaf & Mohammed Zin, 2018). Niemi (2009) highlighted that societal and learning research changes have caused us to reflect on the need for more discourse on learning rather than teaching. Breakstone et al. (2018) indicated that the consequences of not preparing students to assess online material are real and urgent. Educators must act decisively to teach students skills and knowledge they need to navigate the digital landscape to ascertain who are the creators of the information they consume (Breakstone et al., 2018).

Mynbayeva et al. (2018) indicated the new century has brought major changes in didactics and teaching methods. There is a difference between pedagogy of the 20th century and pedagogy of 21st century. The obvious phenomenon is the internetization of society and the proliferation of digital technologies into learning. Students are now considered digital, socially digital, and generation Z (Mynbayeva et al., 2018). Four changes have resulted in a renewal of instructional methods:

- (1) the expansion of the subject of pedagogy;
- (2) environmental approach to teaching;
- (3) the digital generation and changes taking place; and
- (4) innovation in teaching.

In the environmental approach to teaching, the teacher role changes to a facilitator role in the child's development and thus, an art-pedagogical, innovative teaching methods are recommended. This approach consists of the dynamic exchange of information, knowledge, and energy between teachers and students. As a result, in didactics, it is considered more effective to use developing, positively motivating methods and technologies of education that

will engender a development environment that positively influences development (Mynbayeva et al., 2018). Digital generation is evident in the introduction of multimedia in the educational environment. Changes in digital generation include changing from current step, gradual movement to nonlinearity, single tasking to multitasking, books reading to display (visual perception), passive schools to schools as a game, external technology to internal technology, pure mental performance to intellectual internet and communications technologies (ICT) tools, paper and pencil to working on screens, individual performance to making and sharing in groups, and knowledge acquisition to knowledge creation (Mynbayeva et al., 2018). The innovation in teaching methods involves educators continuously enhancing their didactics skills, choosing, and developing new methods and technologies of teaching which is a necessity in today's classroom. Smetana and Bell (2012) posit that effective computer simulation occurs when they:

(a) are employed as supplements; (b) high-quality support structures are incorporated; (c) provide opportunities for student reflection; and (d) foster cognitive dissonance.

Kovacs (2017) highlighted that a progressive innovative school should promote the following:

(1) developing 21st century skills; (2) personalized and individualized learning; (3) hands-on and experiential learning; (4) community-based learning that focuses on locality and the world as a whole; and (5) novel set of credentials (measurements) that include a variety of learning experiences.

In addition to teachers changing their roles to that of facilitators, teachers must also practice reflective teaching. Based on the reflective teaching framework, educators are no longer passive consumers or transmitters of knowledge but producers of knowledge which entail them providing solutions to problems in their own setting (Zeichner & Liston, 1996, as cited in Tezgiden, 2016). The most effective teaching practices consist of a blend of academic knowledge and knowledge of research and theory which include a conceptual map of the educational industry (Orchard & Winch, 2015). Furthermore, when educators use theory and research findings in their practice, they build capacity for self-direction (Orchard & Winch, 2015).

2.4. Employing Artificial Intelligence (AI) in Teaching and Learning in K-12 Education

The emergence of artificial intelligence (AI) in the education industry demands that educational institutions change policies, instructional practices, and assessments that would harness the power of AI to maximize learning outcomes in K-12 and higher education classrooms. Education is considered a pivotal component in creating a future workforce that is AI-ready (Pedro et al., 2019). Coupled with the integration of AI technologies in the learning environment, is the need to rethink the content and methods that are employed to deliver instruction from the kindergarten level to the postsecondary level (Pedro et al., 2019). Artificial intelligence (AI) provides a duality of potential outcomes:

(1) AI has the potential to revolutionize teaching methods, assessment, and learner engagement; and (2) AI creates unexpected long-term influence on student learning and the education system such as critical thinking and problem-solving which are vital in modern complex environments (Dawson et al., 2023). There are numerous applications of AI in education: (a) personalized learning systems, E-learning, and Information and Communication (ICT)-based education and training; (b) automated assessment systems; (c) chatbots; (d) predictive models; (e) intelligent models; and (f) virtual reality (VR) and augmented reality (AR) technologies (Annuš, 2024).

There is a gamut of changes that are occurring in the 21st century including scientific discoveries, informatization, globalization, and the development of astronautics, robotics, and

AI (Mynbayeva et al., 2018). Yim (2024) posits that artificial intelligence (AI) literacy education primarily focused on secondary and university students but not on the needs of primary school students. It is critically important that for effective AI literacy implementation in primary schools there must be identification of AI literacy learning content for these young learners (Yim, 2024).

The widespread cultural integration has engendered a growing demand for people to learn English (Li, 2022). The exponential growth of globalization has resulted a global use of English. However, there are limitations in the traditional teaching methods including a shortage of oral English teaching environments, abandonment of the students' dominant position, outdated teaching mode of English, deep-rooted exam-oriented education, and educators primarily focus on teaching materials. The emergence of artificial intelligence (AI) has led to an innovative solution to the problem of oral language learning (Li, 2022).

2.5. Authentic and Modern Assessment Methods

There is a need for authentic and modern assessment methods that would correctly and comprehensively assess students' knowledge and skills. Zeng et al. (2018) point out that to cater to students' learning needs and requirements of educational policies, researchers and educators have exerted considerable efforts in reforming assessment practices. Swiecki et al. (2022) posits that traditional assessment practices such as multiple-choice questions, essays, and short answer questions, have been used prevalently to deduce student knowledge and learning. However, these practices have several shortcomings including:

(1) teachers find them burdensome to design and administer; (2) they do not provide a comprehensive assessment of students' learning and knowledge but a summary of performance; (3) they may be standardized and thereby not accounting for specific knowledge, skills, and backgrounds of students; (4) they may be outdated, evaluating skills that humans routinely employ machines to perform; and (5) they are not authentically assessing students' knowledge and skills that are required for success in the world but assessing skills required by schools (Swiecki et al., 2022).

Swiecki et al. (2022) highlighted that despite the shortcomings of the standard assessment paradigm (SAP), these forms of assessments remain dominant in today's education system. Assessment is viewed as a critical area that provides opportunities for artificial intelligence (AI) transformative changes in education. Areas for AI assessments include: (a) automated assessment construction; (b) AI-assisted peer assessment; (c) writing analytics; (d) electronic assessment platforms (EAPs); (e) stealth assessment; and (f) computerized adaptive testing systems (CATs) (Swiecki et al., 2022). Like SAPs, there are issues with AI assessment methods:

(1) sidelining of professional expertise; (2) black-boxing of accountability; (3) restricting the pedagogical role of assessments; (4) assessing limited forms of learning; and (5) surveillance of pedagogy (Swiecki et al., 2022).

In addition, Gašević et al. (2023) point out that the challenge for researchers and educational institutions to define and develop a space of negotiation between what artificial intelligence (AI) is and does in learning and the connection to human learning and cognition. For instance, how do educators assess student writing assignments when a paper can be written of high quality using ChatGPT in a few seconds (Gašević et al., 2023).

2.6. Innovative Lesson Planning and Lesson Delivery

With global migration, the diversity of classrooms is rapidly changing in terms of cultural backgrounds, languages, socioeconomic status, academic abilities, and interests. In countries that do not have systems for special needs education result in minimal educational provisions being available to disabled students (Peters, 2007, as cited in Florian, 2014). On the contrary, there are challenges in countries that do have systems for special needs education (Florian, 2014). Research has shown that educators infrequently use guidelines or frameworks when planning their lessons (Koenig, 2024). Prudently structured lesson plans are not frequently used in traditional learning environments that are teacher-centered and results in students being passive learners (Iqbal et al., 2021).

The lesson planning process entails educators reflecting prior to and after delivery of the lesson, interactively thinking during instruction, and grounding their practices in theories and beliefs (Jantarach, & Soontornwipast, 2018). Jantarach and Soontornwipast (2018) proposed a cyclic lesson planning process that consists of preplanning, planning, implementing, and reflecting or evaluating. Iqbal et al. (2021) developed a three-theory based lesson planning process (a schematic diagram of effective lesson plan) that includes the following components: constructivism theory, Gagne's 9 events of learning, formative assessment, lesson plan, and learning outcome.

To create lesson plans and use effective delivery strategies, several factors should inform the process to make learning relevant, meaningful, personalized, actively engaging, and impactful. Pannullo et al. (2025) proposed a theoretical lesson planning framework that uses the Model of Educational Reconstruction (MER) and Universal Design for Learning (UDL) that can evolve to respond to current educational challenges including digitalization and diversity. The cognitive demands of lesson planning (CODE-PLAN) framework consider content, social context, and time as factors that educators as a means of mental orientation during planning of their teaching performance (König et al., 2021). Oller et al. (2021) found that in fostering personalized learning in the classroom, educators must change their focus from making connections between students' learning to their learning experiences that exist at various times and contexts for them to create their own learning trajectories.

Modern teaching practices include fostering collaborative work, connecting content to real-world applications, and inspiring students to play an active role in the learning process (Villar-Aldonza, 2023). Besides connecting content to real-world phenomena, the learning activities and content should consider students' lived experiences to be relevant and meaningful. According to Priniski et al. (2018), relevance is defined as "a personally meaningful connection to the individual" (p. 2). Priniski et al. (2018) conceptualized three types of relevance along a continuum:

personal association, personal usefulness, and identification. Researchers have criticized seemingly linearity of the objectives-oriented model in lesson planning templates because it does not consider contingencies and complexity of teaching, the learning environment, and the influence of external factors including organizational and personal issues (Black et al., 2019). Educators must thoughtfully plan lessons considering various aspects of their lessons including learning activities and instructional practices prior to delving the lesson (Aydin, 2014). A prudently prepared lesson plan should achieve effective, targeted instruction and include such factors as instructional methods, subject content, standards, and backgrounds of students (Strickroth, 2019). In addition, irrespective of the lesson format, a prudently developed lesson plan should include elements such as learning objectives, instructional methods, required materials, and assessment methods (Kizi, 2024).

2.7. Factors That Should be Informing Lesson Planning and Learning Activities

Based on the discussions of the previous sections, lesson planning and learning activities should be aligned with assessment data, student backgrounds, relevant and meaningful, and connected to current events occurring globally. Mynbayeva et al. (2018) highlighted that as it relates to expanding the subject of pedagogy, educational theories propose that besides fostering interaction between students and teachers (the micro level of interaction), there must be interaction between the state and education system, the social groups of students and teachers, parents and students, parents and schools, schools and public organizations, schools and religions, schools and economic, and social development of society (the macro level of interaction). The redefinition of learning in recent years has defined learning as an active individual process, where students construct their own knowledge base and it involves sharing and participating with different stakeholders in a community, and considered a holistic constructing process that is interconnected with students' social and cultural premises (Niemi, 2009).

To enhance education, the national curriculum should be adapted to the specific needs of students and their learning environment (Karataş et al., 2024). Educators are required to alter the standard curriculum to cater to the needs of learners to reflect the local values, interests, and the varied learning styles and backgrounds of their students. Curriculum adaptation is necessary because the one-size-fits-all national curriculum fails to meet the distinct needs of individual students and the school and community contexts (Karataş et al., 2024). Stakeholders in the education industry have come to the realization that a transformation of education must occur for 21st century learners and learning (Kumpulainen & Sefton-Green, 2014). More specifically, stakeholders are demanding an expansion of access to students that is socially rooted, interest-driven, and provides educational opportunities (Ito et al., 2013, as cited in Kumpulainen & Sefton-Green, 2014).

Technologies that currently exist provide opportunities for purposeful incorporation of tools for social linkage and knowledge co-creation and for linking learning environments, communities, and homes. However, despite many educational institutions having these technologies, the question remains whether these technologies are being used effectively to foster meaningful and productive learning that 21st Century learning demands (Kumpulainen & Sefton-Green, 2014). Furthermore, classrooms that stretch across space and time, responding to learners' lives and diversity, require pedagogical innovation and transformation demands (Kumpulainen & Sefton-Green, 2014).

2.8. Globalization and Culturally and Linguistically Responsive Pedagogy

Globalization has resulted in exponential growths in emergent bilingual student populations around the world which require new and innovative teaching methods (Hoover et al., 2018; Tran et al., 2018; Yoon, 2023). Globalization demands comprehensive systemic changes in education which require a paradigm shift from a mono-cultural approach to education to multi-cultural approaches with implications for school curriculum and practices (Misra, 2012). Yoon (2023) described multilingual learners (MLLs) as students whose native language is not English, and they are currently in the process of acquiring English as a new, additional language. It is important to note that MLLs are one of the fastest growing populations in U.S. public schools (Yoon, 2023). For instance, United States classrooms today are defined by cultural and linguistic diversity (Yoon, 2023). Consequently, there is a need for educators to be trained in and employ the research-based practices developed to effectively cater to students that come from diverse cultural backgrounds. Furthermore, in the past few decades, culturally and linguistically responsive teaching (CLRT) has been viewed as the most effective approach to supporting middle grade MLL learning (Yoon, 2023). Furthermore, it is paramount that the

learning needs of a growing number of students with disabilities from the culturally and linguistically diverse student populations are addressed (Tran et al., 2018). Hoover et al. (2018) highlighted that educators must deliver CLRT within the context of special services and maximizing the interaction between exceptionality and diversity for effective education of English learners (Els) with learning disabilities.

2.9. Fostering Active Student Engagement and Conceptual Understanding with Gamification and Simulation Technologies

Simulation and gamification technology play a pivotal role in stimulating interests and fostering active student engagement and conceptual understanding. Gamification and game-based learning are widely used mobile and technological approaches that employ game elements to foster desired behaviors and support corporate learning outcomes (Zainuddin et al., 2020). It is important to point out that gamification is not using games for non-entertainment purposes but rather it uses the elements of a game experience to enhance retention (Faiella & Ricciardi, 2015). There are eight elements of a game that are employed in gamification:

(1) rules, (2) goals and outcomes, (3) feedback and rewards, (4) problem solving, (5) story, (6) players, (7) safe environment, (8) sense of mastery (Faiella & Ricciardi, 2015).

Sailer and Homner (2019) found that the present meta-analysis corroborates research findings that indicate gamification of learning is an effective teaching method because they found significant, positive effects of gamification on cognitive, motivational, and behavioral learning outcomes. Faiella and Ricciardi (2015) defined engagement as students' attention and absorption in a learning activity, but the teacher is delivering the learning activity. It has long been established through research that simulation technologies or computer simulations promote conceptual understanding (Lindström et al., 1993; Zacharia & Anderson, 2003). Widiyatmoko (2018) highlighted that conceptual understanding allows students to transfer an explanation of a phenomenon in different ways which is required in science learning and simulation is one approach to achieving conceptual understanding. Lindström et al. (1993) found that computer microworlds and simulations possess the potential to create extensive and diverse learning experiences of phenomena which contribute to the development of intuitive and conceptual understanding of the phenomena. In addition, Zacharia and Anderson ((2003) found that employing simulations enhanced students' ability to arrive at acceptable predictions and explanations of the phenomena in their physics experiments. For example, Banda and Nzabahimana (2021) indicated a review of literature shows robust findings that PhET simulations can significantly improve students' conceptual understanding of physics and can be incorporated in numerous active learning instructional environments.

2.10. Developments in Teaching Ecosystems

As discussed earlier, this paper presents a novel and innovative teaching and learning ecosystem referred to as the Ferreira's Ecosystem for Teaching and Learning (FETL) Model. An ecosystem is defined as organisms interacting in several connected and diverse parts within their environment (Shu et al., 2023). Sancho-Gil et al. (2020) propose a challenge to the traditional conceptions of learning which primarily focus on cognitive and individual to a paradigm shift that proposes the argument for learning ecosystems where intra-action is the driving force of learning. Furthermore, learning ecosystems account for the discontinuous, non-linear, fragmented, and fractal dimensions of learning consisting of intra-actions between living beings, culture, and matter (Sancho-Gil et al., 2020). More specifically, a learning ecosystem encompasses all supports for students' sustained experiences and embeds factors from home to classrooms and government to governance that influence how students obtain new

knowledge (Regmi, 2024). Regmi (2024) presented an interesting ecosystem for educational institutions that consists of multiple constituents including:

(a) government; (b) learning environment; (c) building; (d) family; (e) learners, (f) instructors; (g) curriculum; (h) strategy; (i) physical space; (j) digital learning. Walcutt and Schatz (2019) describe the future of learning ecosystem as a transformational approach moving away from disconnected, episodic experiences towards lifelong learning customized to students and delivered in various locations, media, and periods of time. The future of learning ecosystems entails significant reimagining of learning and development in which instruction and information delivery methods foster conceptual learning and accelerate the transfer of learning from practice to real-world environments (Walcutt & Schatz, 2019).

3. Why Consider Ferreira's Ecosystem for Teaching and Learning (FETL) Model?

The literature review reveals that traditional teaching and assessment methods, lesson planning and delivery frameworks have become outdated and ineffective in responding to the rapid changes in the education industry resulting from the emergence in artificial intelligence (AI), curriculum and policies, and student demographics. As presented and explained in depth in Ferreira (2022) and as shown in Figure 1, the FETL Model was developed after a critical review of literature on pedagogical and andragogical best practices, prudent rethinking and reimagining of lesson planning and lesson delivery, and consideration of the numerous factors that influence effective lesson development and lesson delivery. The goal is to present an innovative approach to lesson development and lesson delivery that integrates the distinct factors that bring the content to life through the harnessing of the power of the interrelatedness and interconnectedness of the factors. Some potential benefits of using this novel approach include the following:

- It addresses the age-old question: Why do I have to learn this?
- The teacher or educator serves as a facilitator, coach, consultant, or change-agent.
- It revolutionizes lesson planning and delivery through reimagining and redefining the process.
- It is no longer a linear process but a cyclic process.
- It is learner-centered (equity for all students): caters to all learning styles, academic abilities, interests, student experiences, and cultural backgrounds.
- It promotes instructional rigor.
- It promotes data-driven instruction and assessment.
- All components are supported by scholarly research.
- An innovative, holistic, and novel approach to lesson planning and lesson delivery.
- It promotes student-content relevance (students' current interests, future goals, and identities).
- It promotes inclusive classrooms.
- It brings content to life by allowing students to immerse themselves in the learning tasks (Immersive Learning).
- It is easily implemented.
- An effective planning, teaching, and assessment tool.
- It is a valuable resource for informing teacher appraisals or evaluation.
- It transcends standards, content areas, and grade levels.
- It makes teaching and learning relevant, engaging, and enjoyable.
- It increases student active engagement and understanding.

- It promotes inquiry-based/discovery learning, self-directed learning, productive struggle (growth mindset), rigor, and competency-based learning.
- It promotes differentiation and personalization.
- It fosters interdisciplinary and multidisciplinary teaching and learning opportunities.
- It provides opportunities for simulation modeling and role-playing.
- It promotes the 4Cs: Communication, Collaboration, Critical Thinking, and Creativity.
- It promotes conceptual understanding of concepts.
- It incorporates internet communications technology (ICTs) and artificial intelligence (AI); and immersive technologies including virtual reality (VR) and augmented reality (AR).

3.1. Empirical Evidence: FETL Model's Effectiveness and Applicability Research

A research was conducted to obtain empirical evidence on the effectiveness and applicability of the FETL Model across content areas and grade levels (nursery, primary, secondary, and postsecondary). It is important to note that several of the potential benefits listed have been supported with the research findings. A quantitative study employing a quasi-experiment and survey was conducted in one secondary school (four mathematics classes) and two postsecondary institutions (four science classes) in Guyana. Students in the two experimental groups were taught using the FETL Model which included the use of technologies such as gamification (Khahoot! and Quizizz), PhET Simulation website, Padlet (for reflective practices), Demos, GeoGebra, laptops, and smartboards. Students in the control groups were taught using non-technology or traditional methods. Students in the control groups and experimental groups completed a pretest and posttest and their previous term mathematics scores were used as a covariant. Students in the experimental groups completed the Student Experience and Academic Engagement (SEAE) survey to record their learning experiences and attitudes in lessons that were designed using the FETL Model. Statistical tests and analyses were conducted which revealed statistically significant results indicating the experimental groups outperformed the control groups on average on the posttest. Students in the postsecondary institutions only completed the SEAE.

Ferreira (2025) found in a study with one secondary school and two postsecondary institutions in Guyana:

1. The results from a quasi-experiment were statistically significant and corroborated findings outlined in the literature review section. The FETL Model was effective in increasing students' mathematics scores controlling for their previous term mathematics scores.
2. The results of the Student Experience and Academic Engagement (SEAE) survey underscored the importance of incorporating artificial intelligence and other technologies (simulation and gamification), meaningful and relevant learning experiences, culturally and linguistically responsive pedagogy, innovative lesson planning frameworks, reflective practices, and the 4C's (Communication, Creativity, Critical Thinking, and Collaboration) at all levels of schooling including nursery, primary/elementary, secondary, and postsecondary.

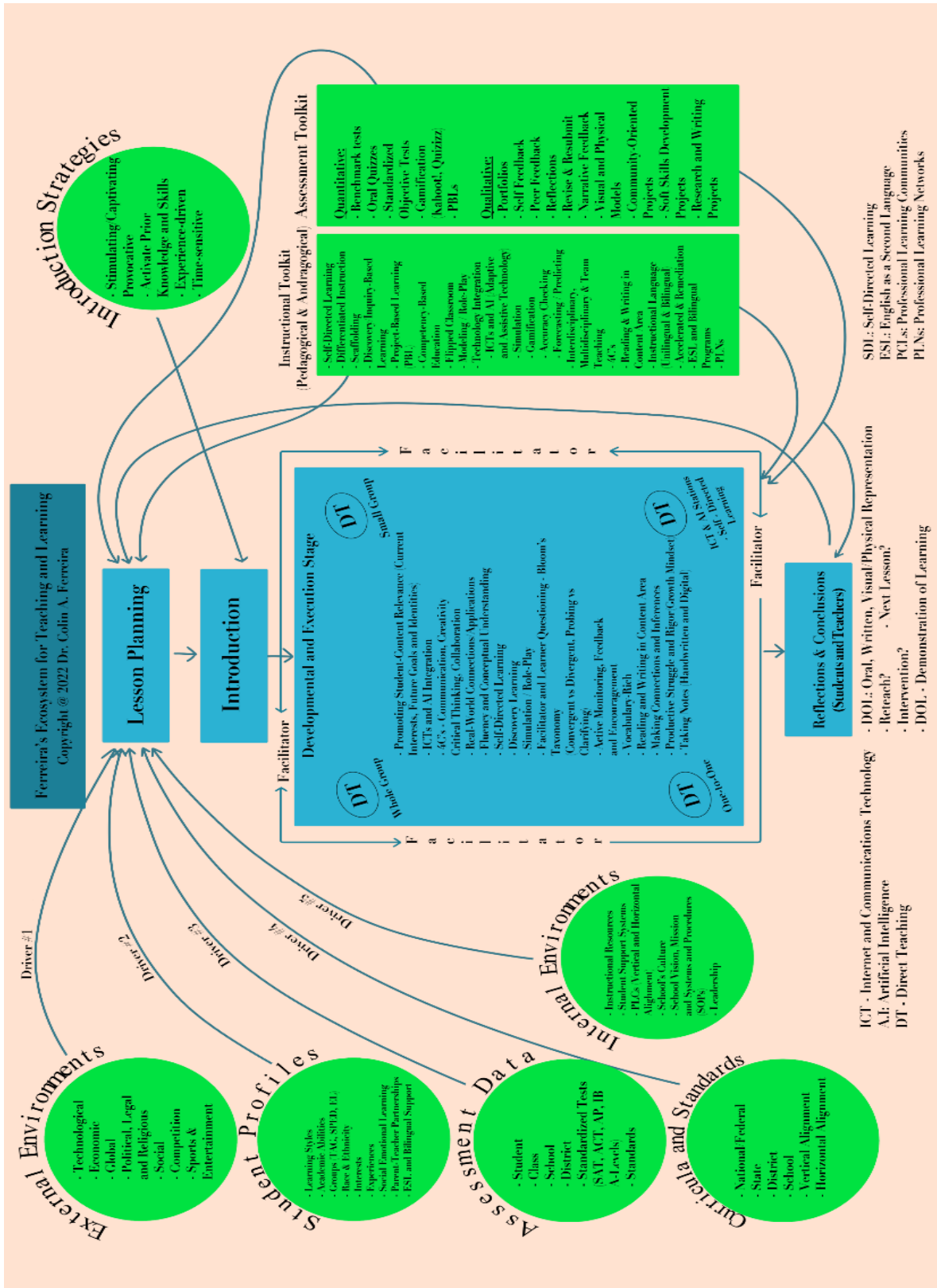


Figure 1. Schematic illustration of Ferreira's Ecosystem for Teaching and Learning (FETL) Model

3.1.1 FETL Model Zoomed In



Figure 2. Driver #1: External Environments

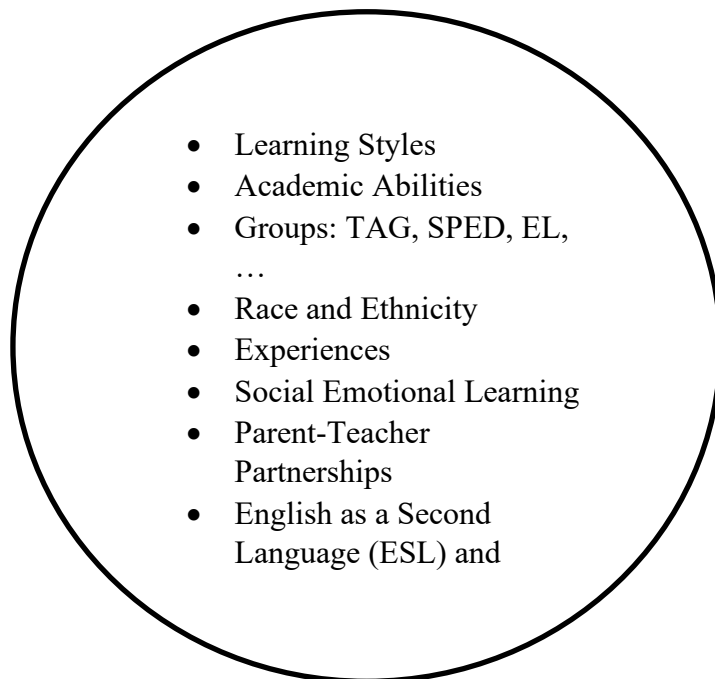


Figure 3. Driver #2: Student Profiles

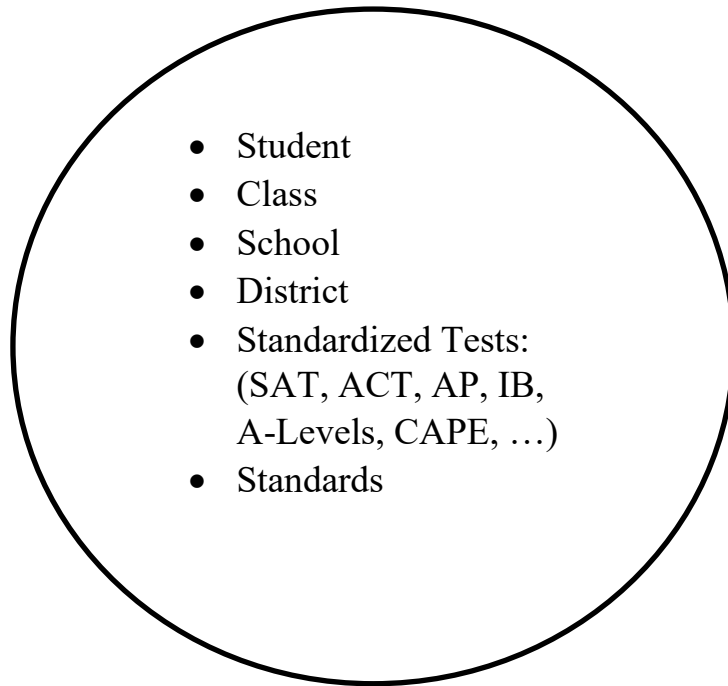


Figure 4. Driver #3: Assessment Data

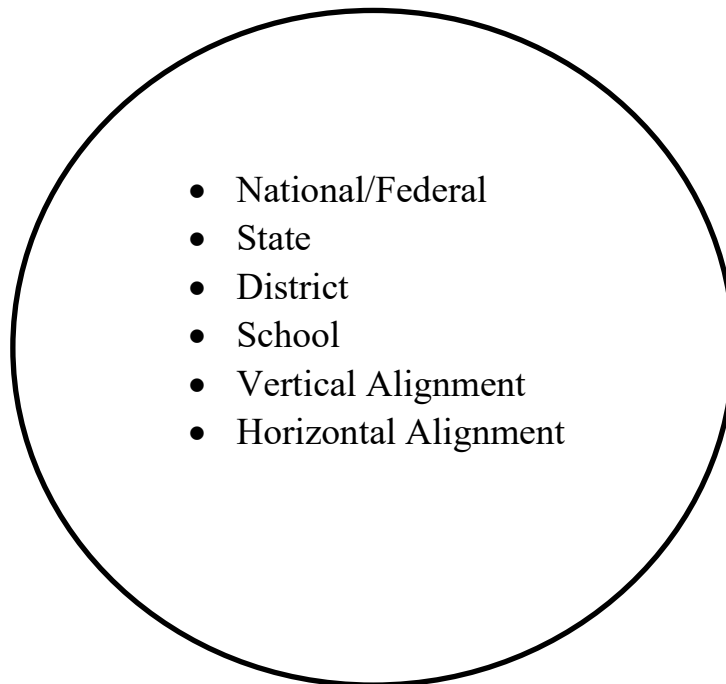


Figure 5. Driver #4: Curricula and Standards

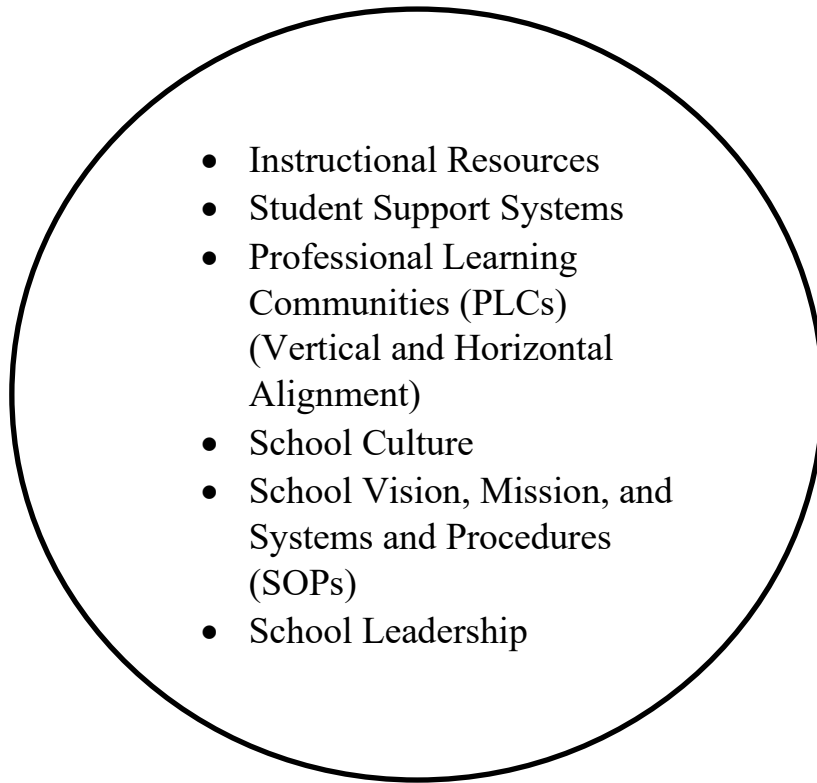


Figure 6. Driver #5: Internal Environments

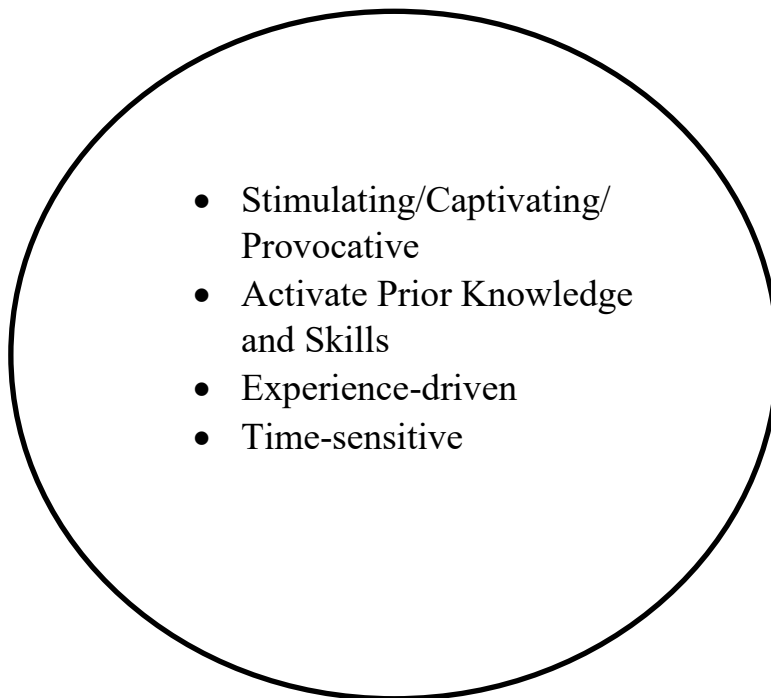


Figure 7. Introduction Strategies

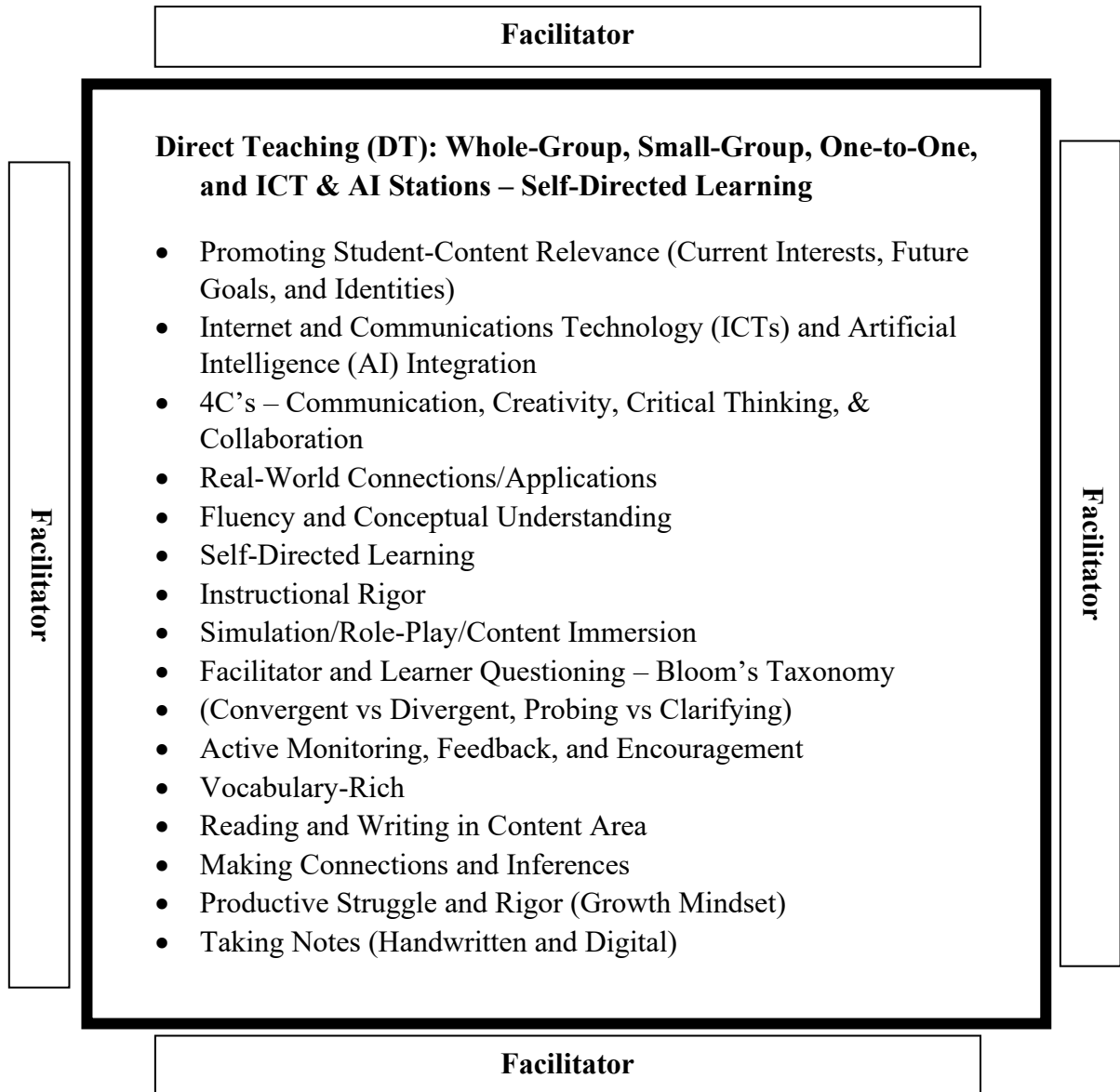


Figure 8. Development and Execution Stage

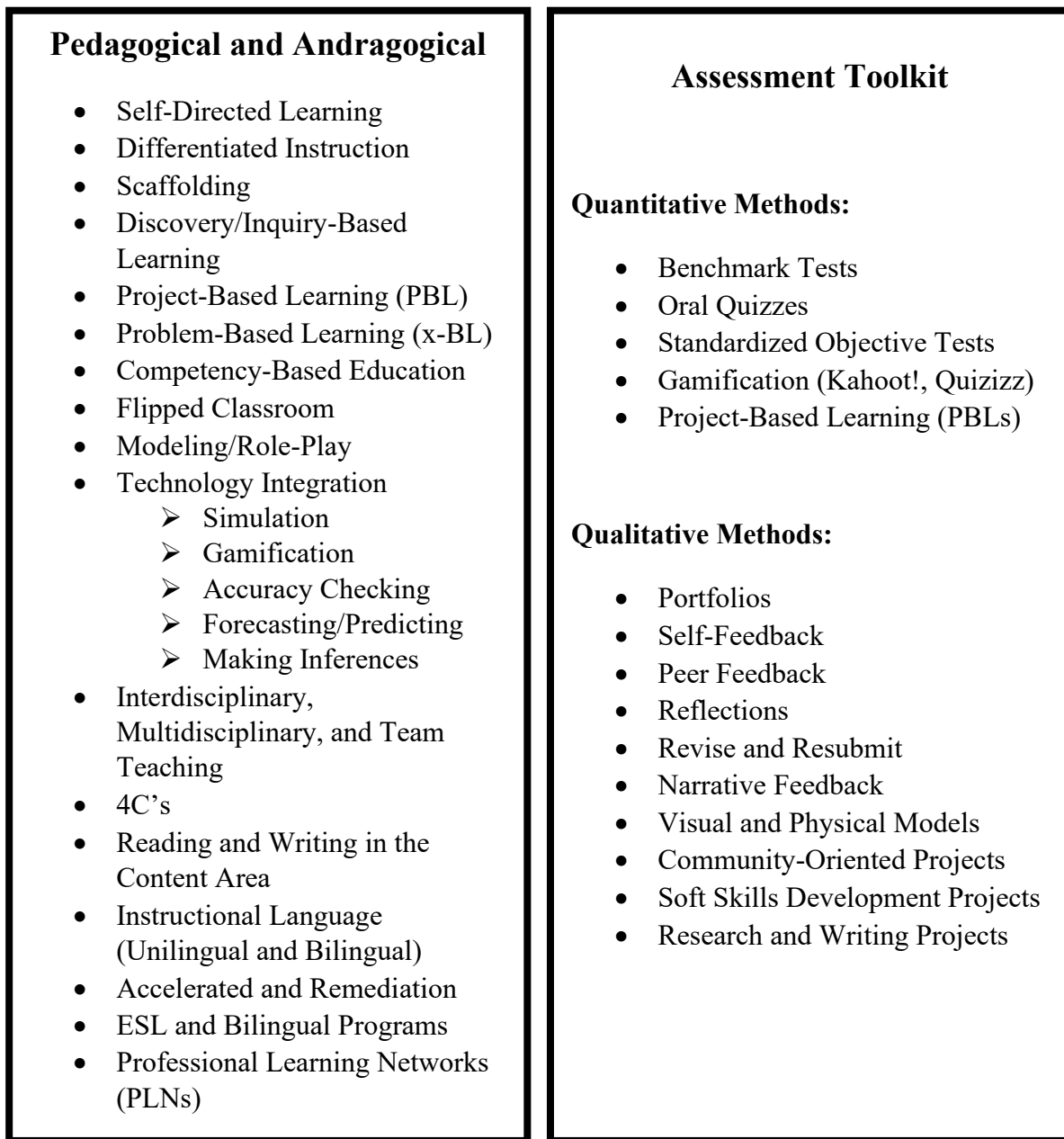


Figure 9. Instructional and Assessment Toolkits

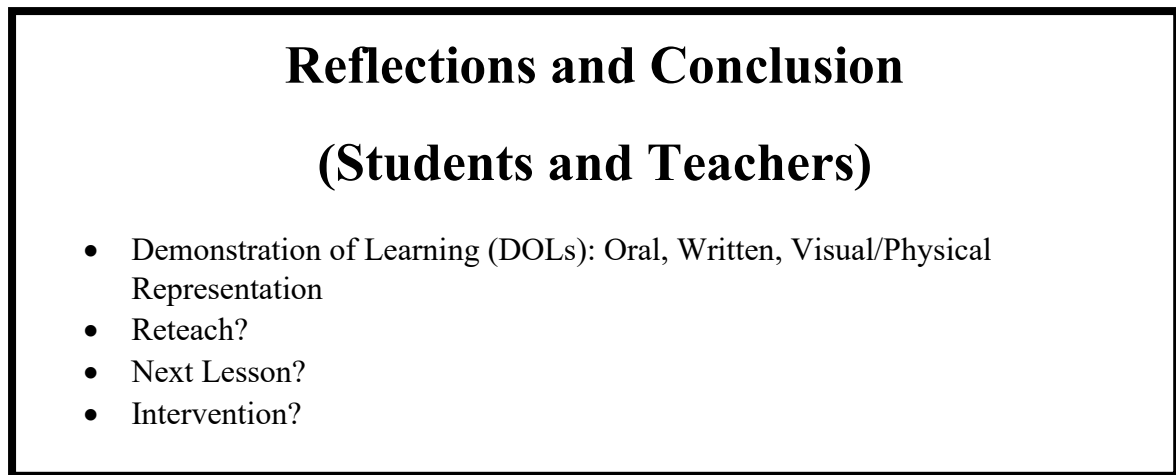


Figure 10. Reflection and Conclusion

3.1.2 Abbreviations that are used in the FETL Model Schematic Illustration:

- ICTs – Internet and Communications Technology
- AI - Artificial intelligence
- DT – Direct Teaching
- DOL – Demonstration of Learning
- SDL – Self-Directed Learning
- ESL – English as a Second Language
- PLCs – Professional Learning Communities
- PLNs – Professional Learning Networks
- PBL – Project-Based Learning
- xBL – Problem-Based Learning

4. The FETL Model Underscores the Importance of Thoughtful Lesson Planning and Delivery

Since the 90s and before, scholars have articulated the importance of thoughtful lesson planning and its positive effects on teaching and learning. Based on my decades of teaching experiences and the FETL Model research, prudently planned lessons that take into account a range of factors beyond curriculum and standards, or learning objectives or outcomes, make learning relevant, engaging, rigorous, and promote deeper conceptual understanding, retention, critical thinking, and sense-making of concepts through the connections that are made to everyday experiences and real-world phenomena. Johnson (2000) posited that excellent teaching does not occur by chance but through thoughtful planning which is necessary for effective lessons and enhanced learning.

Effective lesson design provides opportunities for students to explore, obtain and synthesize information and define and solve problems (Seamon, 1999). A lesson that is not prudently planned is one that is not impactful on learning (Baker & Fleming, 2005). Instructional strategies and assessment must be developed to foster unambiguous and beneficial objectives (Baker & Fleming, 2005). Lesson plan development is attributed to the potential failure of students with disabilities in general education classrooms (Spooner et al., 2007). Universal Design for Learning (UDL) is a recommended solution that special education and general education teachers can employ to design lesson plans that cater to the diverse student

populations (Spooner et al., 2007). Efficient lesson planning using the UDL framework empowers teachers to reach all students' learning needs more effectively (Courey et al., 2013).

The FETL Model works well with all lesson planning frameworks including the UDL framework, Hunter's (1982), and Causton-Theoharis et al. (2008). The UDL framework supports pedagogy that encompasses curricular materials, technologies, and instructional strategies that provide multiple opportunities for representation, action and expression, and engagement (Courey et al., 2013). Representation is defined as creating instructional materials that make the content accessible to the largest number of students. Providing multiple representations of a concept increases deeper engagement with the concept and reaches a wider variety of learners. Action and expression are accomplished by providing alternative ways for students to communicate and demonstrate their learning (such as interviews or creating representations). Engagement is achieved by invoking students' interest and motivation to learn through innovative, practical, and relevant instruction (Courey et al., 2013). The FETL Model promotes both quantitative and qualitative forms of assessments and multiple forms of instruction and learning activities to acquire a comprehensive and fair assessment of students' understanding and mastery of content. The UDL provides opportunities for teachers to provide multiple forms of participation and assessments which are beneficial to both students and educators (Courey et al., 2013).

The FETL Model emphasizes the importance of a stimulating introduction of concepts. Milkova (2012) stated that developing a creative introduction to the topic helps to stimulate interest and enables thinking. There are several ways in creating a stimulating introduction which include personal anecdote, historical event, thought-provoking dilemma, real-world phenomena, short video clip, practical application, and probing question (Milkova, 2012). Research findings have shown that instructional planning plays a pivotal role in teaching and school learning (Baylor et al., 2001). Reiser and Dick (1996) approach recommends the following systematic steps to instructional planning: (a) identifying instructional goals; (b) identifying instructional objectives; (c) planning instructional activities to employ; (d) choosing instructional media and resources; (e) developing assessment tools; (f) implementing the instruction; and (g) revising the instruction (Baylor et al., 2001).

5. Implementing Ferreira's Ecosystem for Teaching and Learning (FETL) Model

5.1. Stage One: Lesson Planning Stage

Whether it is Florida English Language Arts (ELA) Benchmarks for Excellent Student Thinking (B.E.S.T) Standards, Georgia Science Standards of Excellence, Texas Essential Knowledge and Skills (TEKS) for Math, Wyoming Health Education Content Standards, Common Core State Standards, Advanced Placement (AP), International Baccalaureate (IB), A-Levels Standards, Caribbean Advanced Proficiency Exam (CAPE) Standards, or any other state or country standard, a thoughtfully planned lesson is the impetus for a well-executed lesson which in turn is the impetus for effective teaching and relevant learning. Figures 1 to 10 were taken from Ferreira (2022) which provides detailed explanations of the FETL Model. All five drivers: External Environments (Figure 2), Student Profiles (Figure 3), Assessment Data (Figure 4), Curricula and Standards (Figure 5), and Internal Environments (Figure 6) must be considered to make the learning experiences relevant, engaging, and representative of the rich diversity of the students' cultural backgrounds, abilities, interests, experiences, and learning styles. Current and past events or phenomena should be used as teachable moments that are aligned with curricula, standards, and learning objectives. Teaching and learning must not be done in a vacuum because the five drivers directly or indirectly impact students' lives. It is

important to note that the items in each driver are by no means exhaustive and other items can be added to reflect new developments within each driver.

Below are examples of teachable moments that can be incorporated into lesson planning and lesson delivery:

- President Donald Trump signed an executive order in January 2025 to ban birthright citizenship in the United States. How can this ban be interpreted, discussed, or evaluated using concepts in History, Geography, Economics, Political Science, International Relations, English Language Arts (ELA), and Psychology classes?
- How can students in Mathematics, History, Economics, and Business classes interpret, explain, or assess the effects of the 2024 Inflation rates and escalating cost of living in the United States and across the globe?
- How can students in Political Science, Law, Psychology, Gender Studies, and Sociology discuss, interpret, and evaluate the historic and far-reaching effects of the Supreme Court's Reversal/Overturing the *Roe v. Wade*, the constitutional right to abortion?
- How can students' learning styles, academic abilities, career interests, cultural backgrounds, military, and college aspirations be incorporated in the teaching and learning activities to promote inclusivity, active engagement, and relevance?
- How can the COVID-19 Pandemic and the 2022 Monkeypox Outbreak be mathematically modeled by Mathematics students using exponential and logistic functions, Correlation and Regression to better understand their rapid rates of global spread, infections, deaths, and recovery or flattening of the COVID-19 curve and herd immunity?
- How can students in Government, Political Science, Law, and History classes discuss and interpret government corruption, scandals, and subsequent government collapses in the world including the recent events surrounding the United Kingdom (UK) Prime Minister, Boris Johnson's resignation?
- How can students in Physics and Mathematics (Statistics and Calculus) evaluate speed, velocity, and player statistics in track and field, swimming, football/soccer, and cricket by assessing some of the world's greatest athletes including Usain Bolt, Elaine Thompson-Herah, Shelly-Ann Fraser-Pryce, Michael Phelps, LeBron James, Randy Moss, Lionel Messi, Cristiano Ronaldo, Edson Arantes (Pelé), Ronaldinho, Brian Lara, and Shivnarine Chanderpaul?
- How can students in Physical Education classes evaluate the effectiveness of using advanced technology to manage athletes and make critical informed decisions regarding their optimal performance (vital signs and game Statistics) in real time and remotely?
- How can students in Computer Science classes discuss the ethical issues of artificial intelligence, virtual reality, augmented reality, and internet of things in industries regarding the security, safety, plagiarism, and misuse of confidential information and job loss concerns?
- How can Geography students use Google Maps, GPS, and virtual reality (VR) technology to immerse themselves in examining concepts in Geography?
- In August 2022, the FBI searched the former President of the United States, Donald Trump's Mar-a-Lago home. How can students in Law, Politics, Government, and International Relations compare this incident with that of Hilary Clinton's Benghazi email incident?

5.2. Stage Two: Lesson Introduction Stage

As shown in Figure 7, the lesson introduction stage should be dynamic in terms of activating prior knowledge, incorporating student experiences, and stimulating critical thinking. All lessons should not be introduced the same way with every topic. Sometimes a provocative statement, a short video of a past or present phenomenon (for example, George Floyd's death in the United States or the 2008 Massacres in Guyana) in the external environments, or a hands-on activity that can invoke and capture students' attention and foster engagement. It is important that the introduction is not too lengthy but within a 10-minute timeframe.

Some examples of provocative introduction statements are:

1. Given his criminal convictions and pending legal cases, what do you think is responsible for President Donald Trump's second landslide national election victory in the 2024 United States presidential elections?
2. What is the likelihood that the Miami Heat wins the 2025 NBA Finals?
3. Given Willard Smith's physical assault on Chris Rock, what are his chances of winning another Oscar or acting in a major box office movie?

5.3. Stage Three: Developmental and Execution Stage (Lesson Delivery Stage)

The Developmental and Execution Stage (Figure 8) makes up the bulk of the facilitating and learning time. In this stage the teacher's role is simply that of a facilitator of learning. The teacher should employ one or more strategies from the Instructional and Assessment Toolkits (Figure 9). Several forms of instructional strategies must be incorporated including whole class, small groups, one-to-one, and self-directed (ICT and AI stations) to cater to the needs of all learners. The teacher must have a change in mindset and practice from the giver of all information and solutions and the expert of all things (omniscient mindset) to facilitating the learning experiences through providing opportunities for discovery learning/inquiry-based learning, simulation modelling (content immersions using VR and other immersive technologies) and role-play, hands-on learning, reading and writing in the content area, making inferences and predictions, and incorporating students' life experiences to mention a few.

The fourth industrial revolution (IR 4.0) has transformed the landscape of educational innovation resulting in Education 4.0 (Shahroom & Hussin, 2018). Furthermore, the fourth industrial revolution (IR 4.0) or the Cyber-Physical Systems Era has transformed the teaching and learning landscape, and therefore, schools must invest in creating classrooms that are Education 4.0 compliant (Shahroom & Hussin, 2018). Technology (both adaptive and assistive) plays a pivotal role in self-directed and personalized learning. Technology should not be used only for didactic purposes but for diving deeper into the concepts through simulating dangerous science experiments, mathematical modeling, checking solutions, making predictions and inferences, and promoting conceptual understanding, critical thinking, rigor, creativity, and collaboration.

A plethora of simulation software and apps as well as adaptive/assistive and immersive technologies can be used to foster self-directed learning and personalization (differentiation) including Desmos and GeoGebra for Mathematics, PhET Interactive Simulations and PraxiLabs for Sciences, Rosetta Stone, Duolingo, and Babble for World Languages, and Grammarly and Zotero Citation Generator for ELA and research across content areas. Harnessing the power of artificial intelligence, virtual reality (VR), augmented reality (AR), mixed reality (MR), and internet of things (IoT) can transform the teaching and learning landscape, but ethical considerations must also be at the forefront of using these advanced technologies.

Questioning types (based on Bloom's Taxonomy) and questioning techniques should be taught to both students and teachers so higher-order questions can occur during discussions. Both teachers and students should employ a range of question types and questioning techniques including convergent, divergent, probing, wait time, redirection, prompting, and clarifying to foster critical thinking, increase deeper understanding, and produce a diversity of perspectives. It is important that students take copious notes either handwritten or digitally and the learning tasks must be student-content relevant (current interests, future goals, and identities). The facilitator must be actively monitoring students during independent or group work and providing immediate feedback to address any misconceptions and misunderstandings and offering the necessary encouragement. Learning tasks should have time limits, and a time countdown system must be in place either through the smartboard, clocks, or verbal reminders to keep students on task and engaged. This stage should lead to some lightbulb moments that are linked to the learning outcomes. Opportunities must also be provided for peer, interdisciplinary, and multidisciplinary teaching and learning. Content areas must not be taught in isolation or a vacuum and Professional Learning Communities (PLCs) including vertical and horizontal alignment must involve teachers from the same content area and different content areas to address common topics and challenges.

Rigorous learning tasks lead to more lightbulb moments and should be the driving force behind discovery learning. A rigorous learning environment is one where all students are expected to learn at elevated levels, are supported to learn at elevated levels, and exhibit evidence of elevated levels of learning through the guidance of a facilitator equipped with subject matter expertise (SME) and employing pedagogical best practices (Blackburn & Williamson, 2013). Rigor and student engagement strive in a learning environment that has strong student-teacher relationships, student-content relevance that focuses on students' current interests, future goals, and identities, and teacher-content competence which consists of a teacher's subject matter expertise, pedagogical, and social skills that ensure effective delivery of the content knowledge and skills.

Furthermore, opportunities for soft skills development, social emotional learning (SEL), building positive relationships with students (student rapport) and parents, and exposing students to community-oriented projects (Project-based Learning) will complement the academic knowledge and skills (hard skills) to promote the holistic development of all students. Establishing partnerships with employers to provide opportunities for internships so students can acquire real-world work experiences to reinforce concepts taught while simultaneously developing soft skills (both interpersonal and intrapersonal skills). Aligning curricula and learning activities with the needs of employers can equip students with the requisite entry level knowledge and skills.

Finally, group work and group members should be carefully chosen by both the teacher and students, but a balance must be maintained in each group based on students' academic background, interests, and schedule where practical. This balance will foster opportunities for multidisciplinary and interdisciplinary teams working on a solution to a problem. For example, a research project on flash floods should include students from Statistics, English Language Arts (ELA), Geography, and Government among other content areas. Throughout the teaching and learning process, students must receive their designated support including inclusion teachers, English as a Second Language (ELS), and bilingual teachers to enhance learning experiences. Furthermore, students must be given learning activities that focus on Reading and Writing in the Content Areas and using content-specific vocabulary (communicating in the language of the content area) throughout the teaching and learning process.

5.4. Stage Four: Reflections and Conclusion Stage

In this stage (Figure 10), the facilitator assesses students' learning relative to the learning outcomes through either formative or summative assessments. It is important that a variety of quantitative and qualitative assessment methods are used to get a complete understanding of students' progress and performances. A single test does not give a complete explanation of the students' knowledge and skills to a particular standard because there are many factors that can negatively impact a student's scores on a high-stakes test. While the quantitative methods (such as benchmark tests) provide essential information on mastery of standards and deficient areas that inform lesson plans, instruction, and necessary interventions, qualitative methods (such as portfolios and self-feedback) can help explain and understand the test scores and provide other ways of assessing students' knowledge and skills under comfortable and stress-free conditions. The assessment results should be used to inform the next lesson so that misconceptions and deficiencies can be addressed, and improved learning can occur. Based on both quantitative and qualitative analysis of the students' work, the facilitator will make the appropriate decision including moving on to the next standard, implementing student-specific intervention, or whole class reteach.

5.5. The Reflective Teacher

In the Reflections and Conclusion Stage, students and teachers will reflect upon the lesson and learning outcomes. Students can write on sticky notes or in their journals what they have learned, did not understand, or need more explanation. As it relates to the teacher, this reflection process is conducted daily to determine his or her teaching effectiveness, professional growth, and development, and design creative ways to meet all learning needs. There are several definitions for reflective teaching or the reflective teacher. Bartlett (1990) points out that:

Becoming a reflective teacher involves moving beyond a primary concern with instructional techniques and "how to" questions and asking "what" and "why" questions that regard instructions and managerial techniques not as ends in themselves, but as part of broader educational purposes (Richards, 1995, p. 1).

There are a variety of approaches that teachers can use to become critically reflective teachers including observation of themselves and others, team teaching, and exploring one's view of teaching through writing (Richards, 1995). The reflection process involves three stages:

1. The event itself (the actual teaching episode such as the lesson).
2. Recollection of the event (a reflective examination of what occurred or the experience).
3. Review and response to the event (taking necessary actions are reviewing the event) (Richards, 1995). Teachers can reflect through a range of media including reflective journals. Reflective journals are used to enable teachers to reflect on their teaching which results in feedback for the enhancement of their classroom practices (Zulfikar & Mujiburrahman, 2018).

6. Conclusion and Implications

Based on the literature review, there is an urgent need to reimagine and redefine effective lesson planning and lesson delivery to respond to the radical changes stemming from the emergence of artificial intelligence (AI) in education, globalization (student demographics), policies, and curriculum. Traditional teaching and assessment methods, and lesson planning frameworks are now considered antiquated and are no longer effective in fostering meaningful, engaging, and relevant learning experiences. The proposed Ferreira's Ecosystem for Teaching and Learning (FETL) Model has the potential to revolutionize the lesson planning and lesson delivery process by incorporating the various components to foster personalized and immersive learning experiences using adaptive and assistive technologies, augmented reality (AR) and virtual reality (VR) for content immersion and simulation, administering authentic and AI-driven assessments, connecting learning activities to students' lived experiences, cultural backgrounds, and interests (culturally and linguistically responsive instruction and learning activities). Despite the primarily theoretical nature of this paper, the proposed FETL Model potential was thoroughly discussed. Future work will include more empirical testing and refinement of the model in real classroom settings. Limitations include difficulties that may arise when accounting for the diverse global educational contexts. Future research will include evaluating the proposed model's effectiveness and applicability across disciplines in nursery and primary schools.

As indicated, Ferreira (2025) found that the FETL Model was effective in increasing students' Mathematics scores controlling for their previous term Mathematics scores. As stated by Ferreira (2025), the results of the Student Experience and Academic Engagement (SEAE) underscored the importance of incorporating artificial intelligence and other technologies (simulation and gamification), meaningful and relevant learning experiences, culturally and linguistically responsive pedagogy, innovative lesson planning frameworks, reflective practices, and the 4C's (Communication, Creativity, Critical Thinking, and Collaboration) at all levels of schooling including nursery, primary/elementary, secondary, and postsecondary. The results show that the FETL Model is a novel and innovative lesson planning and lesson delivery framework that is applicable across content areas and grade levels in K-12 classrooms and postsecondary classrooms. These findings have implications for educational policymakers, school administrators, practitioners, teacher training programs, curriculum and assessment developers, and other key stakeholders in education. One such finding is that to effectively instruct the culturally and linguistically diverse students (rapidly growing emergent bilinguals), school leaders and teachers at all levels (nursery, primary, and secondary) must be trained continuously in culturally and linguistically responsive pedagogies.

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