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Research Objective Part 1
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Context

The research question involves determining whether an AI tool that promotes Personalized Learning in a virtual environment using an Intelligent Tutoring System, can produce a significant difference in critical thinking and cognitive capabilities, as evidenced by higher performance on formative assessments.

In an era when political, economic, and social pressure impacts educational leaders to produce results on summative assessments, the direct impact on teachers becomes greater, not only in terms of delivering content, but also in identifying stressors among their students that may preclude optimal performance on assessments. Other metrics germane to institutional success, such as truancy and dropout rates, depend largely upon teacher observation and evaluation to detect early signs of stress, to trigger interventions to provide support that keep learners fully engaged in school.

There are deeper reasons for identifying stressors and other obstacles to learning. Producing citizens that can contribute to society in meaningful ways is the defining quality of constructivist education, and the principles of active learning, and represent essential "praxis" for educators (Kemmis, 2007). The need to foster student collaboration, to improve argumentation and evaluation of evidence, to hone speaking and writing skills, and to cultivate critical thinking across all age groups – all of these are foundational in developing well-rounded individuals and equipping them to participate meaningfully in our democracy.

The challenge in asking educators to instruct and to counsel becomes more acute as budgets are cut, resources are diminished, and social dissonance increases, particularly in public school settings. This project attempts to offer a solution to address limited resources - to deliver AI-driven tools that can help to identify learners in "vulnerable or exceptional situations, enabling educational authorities to take suitable actions that are aligned with students' needs" (Demartini et al., 2024) and thus to refactor instructional designs and bring various services to bear in order to more efficiently address student needs. Researchers point out that data gathered through such tools could offer valuable insights to "teachers and principals, and extending to broader governing bodies" (ibid., p. 1), potentially improving the quality of the educational experience holistically.

Research Approach

1) Two cohorts will be identified - two sections of the same 12-week course offered at the same time. Both will undergo initial knowledge and cognitive assessments. One will have access to the ITS, which will contain this information in a continuously updated database, while the other's (call them Cohort 2) information will in static form.
2) Both cohorts will have the same lessons delivered virtually. Course management will feature instructors who field questions and offer context similarly. The ITS cohort will have online tutoring and knowledge support, while Cohort 2 will rely upon instructor and adjunct support.
3) Learner responses will be gathered at least once during each daily lesson, mainly through quizzes (T/F, multiple choice), short answer challenges, and modeling exercises (Schroeder, et al., 2017), (Wendt & Murphy, 2016) that map directly to the learning objectives (see Appendix). The ITS cohort's responses will instantly update the database (integrated to the learning management system (LMS)), which will help inform the

efficacy of the instructional approach. Cohort 2's responses will be captured in a static database within the LMS.

4) Data ingestion and analysis. The data captured will include correct/incorrect responses, and analysis of short answer responses. For the ITS cohort ingestion will be instantaneous and will also include time taken for each response, patterns of responses, changes to responses, and other indicators of confidence. It will also generate analytics on demand. Cohort 2's data will require integration with LMS, instructor and tutor observations, and other inputs to generate comparable analytics on an ad hoc basis.
5) Assessment. Both cohorts will have formative assessments at three points during the term, culminating in a summative assessment in week 12. These assessments will be formed on the basis of "levels" (Ruiz-Primo, et al., 2002) to more closely evaluate breadth and depth of learning.

Timeline

The timeline below consolidates the lesson plan, assessment types and levels, and the rationale for collecting assessment information.

Weeks	1	2 - 3	4 - 5	6 – 7	8 – 9	10 – 11	12
Lesson	Introduction to Sustainability – Biotic and Abiotic components	Ecosystem Diversity	Ecosystem Productivity	Ecosystem Adaptation	Ecosystem Stability	Ecosystem Impacts and Factors for Sustainability	Course Review
Assessment	Quizzes	Quizzes / Short Answer Formative Assessment	Quizzes / Short Answer	Quizzes / Short Answer Formative Assessment	Presentation / Conceptual Model Formative Assessment	Term Paper / Formal Model	Summative Exam
Assessment Level	Close	Close	Close	Close	Proximal	Proximal / Distal	Distal
Rationale	Confirm retention of basic concepts of biotic and abiotic components. Demonstrates evidence of collaboration and interaction.	Can define and compare elements of diversity Demonstrates evidence of collaboration and interaction	Can define and compare elements of ecosystem productivity. Demonstrates evidence of collaboration and interaction	Can define and compare elements of ecosystem adaptation and articulate how it relates to diversity and productivity. Demonstrates evidence of collaboration and interaction	Can define and compare elements of stability, productivity and articulate how it relates to adaptation, diversity and productivity. Evidences model building capability by developing a high-level conceptual model of a sustainable ecosystem Demonstrates evidence of collaboration and interaction	Can synthesize all concepts presented, identifying both common and distinct features. Evidences model building capability by developing a structural model of a sustainable ecosystem containing inputs, processes, and outputs represented as nodes and links. Demonstrates evidence of collaboration and interaction	Evidences mastery of all concepts presented in the course.

References

Kemmis, Stephen and Smith, Tracey (eds.) (2007). *Enabling Praxis: Challenges for education*. Rotterdam: Sense.

Ruiz-Primo, M. A., Shavelson, R. J., Hamilton, L., & Klein, S. (2002). On the evaluation of systemic science education reform: Searching for instructional sensitivity. *Journal of Research in Science Teaching, 39*(5), 369–393.

Schroeder, N. L., Nesbit, J. C., Anguiano, C. J., & Adesope, O. O. (2017). Studying and constructing concept maps: A Meta-Analysis. *Educational Psychology Review*, *30*(2), 431–455. https://doi.org/10.1007/s10648-017-9403-9

Wendt, T. & Murphy, K. (2016). Integrating Modeling Steps into the High School Curriculum. *The Mathematics Teacher*, *109*(5), 374. https://doi.org/10.5951/mathteacher.109.5.0374

Appendix

This lesson covers topics on sustainable ecosystems, defined as the interaction between biotic (living) and abiotic (non-living) components in an integrated environment. Sustainable ecosystems also have the following characteristics:

- Diversity: The ecosystem maintains its essential diversity of major functional groups
- Productivity: The ecosystem maintains its productivity through survival and procreation mechanisms
- Adaptation: The ecosystem maintains specialized systems to interact with and adapt to changes in the environment
- Stability: The ecosystem maintains interactive controls, such as climate, soil, and disturbance regime, with variations returning toward an equilibrium state.

The curricular framework will involve a multimedia presentation of these topics, delivered through a virtual medium (e.g., Zoom). An ITS tool will be embedded in each student's virtual environment, using baseline data gathered during the pre-testing phase, incrementally adding data on student performance and cognitive evidence, and reformulating the presentation of material based upon updated data.

Learning objectives for this module include the following:

1) Define an ecosystem in terms of diversity, productivity, adaptation, and stability.
2) Describe the interaction between the biotic and abiotic components of the ecosystem.
3) Analyze the criteria making an ecosystem sustainable, as well as stable (tending toward equilibrium)
4) Articulate evidence of causes of sustainability issues and the degree of control societies can exert on those causes.

The assessments will take a situative approach uses three different "levels" of assessment: close, proximal, and distal (Ruiz-Primo, Shavelson, Hamilton, and Klein, 2002).

- For objectives 1) and 2), at the close learning level, knowledge is evidenced through quizzes that reflect collective participation in social discourse (since all lectures implement significant discussion and interaction), measuring retention during the presentations and discussions.
- For objective 3), at the proximal level, evidence of learning is through a cognitive/ representational model. Students will prepare a presentation that illustrates a model, featuring the key factors of sustainability in an ecosystem (i.e., heat, light, air quality, moisture, soil, etc.), and presents evidence of student's ability to formulate, interpret, and validate their model (Wendt & Murphy, 2016).
- For objective 4), at the distal level, learning is conceptualized using the associationist view of learning that evidences the understanding of multiple causes of sustainability impact, the degree of control that can be exerted on these causes, and the political, social, and economic forces that are brought to bear to create change. This will be evidenced through a research paper that comprises the learnings from the course and conveys compelling arguments for the selected course of action.