NEEDS ANALYSIS

Teaching Genetics in Biology 30 using Problem Based Learning

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INTRODUCTION

Understanding genetics is a cornerstone of modern biology education, offering insights into the mechanisms of inheritance, the molecular basis of life, and the ethical and societal implications of genetic technologies. The Biology 30 unit on genetics, delivered online in a synchronous format, aims to engage high school students with foundational knowledge in biology through a problem-based learning (PBL) approach. This method not only aligns with contemporary educational standards that emphasize inquiry, critical thinking, and collaboration but also prepares students to tackle real-world challenges in science and society.

The target audience for this unit consists of Adult Basic Education (ABE) high school level students who thrive on engaging, inquiry-based learning experiences but may face challenges in comprehending abstract genetic concepts such as inheritance patterns, chromosomal mutations, and gene editing technologies. These students also vary in their research and collaboration skills, requiring structured support to navigate complex problems and work effectively in groups. Problem-based learning is particularly suited to this context as it immerses students in realistic scenarios—such as ethical dilemmas surrounding genetic screening or the societal impacts of CRISPR technology—allowing them to apply theoretical knowledge in practical, meaningful ways. By integrating PBL into a synchronous online environment, this unit leverages collaborative tools and virtual simulations to provide an interactive, student-centered learning experience that addresses diverse needs and fosters a deeper understanding of genetics.

This needs analysis examines the current state of the course, its learning objectives, and the specific challenges students face, while proposing targeted strategies to enhance its design and implementation. The goal is to ensure that this unit not only meets educational standards but also equips students with the knowledge, skills, and ethical awareness necessary to succeed in both academic and real-world contexts.

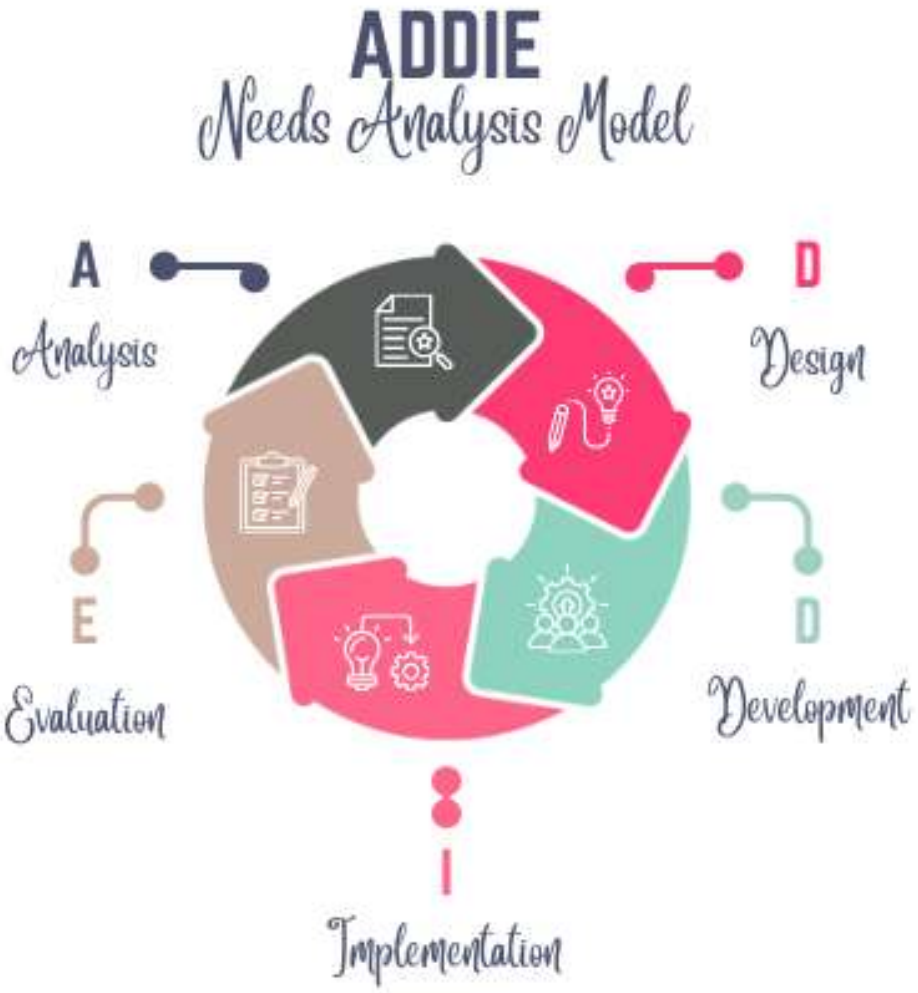

Figure 1: Addie Cyclical Model

ANALYSIS

Current State of the Course

The Biology 30 course offered through Literacy and Adult Education (LAE) at Saskatchewan Polytechnic is delivered synchronously online, with a unit dedicated to teaching genetics. The current instructional approach prioritizes skill-

based assessments over rote memorization, encouraging students to develop practical competencies in genetic analysis and problem-solving. Students are tasked with independently researching topics to deepen their understanding of genetic concepts. While this self-directed approach fosters autonomy, it presents challenges for learners who may lack the necessary scaffolding to navigate complex topics effectively. The absence of physical lab access further necessitates reliance on virtual tools, which, while functional, may limit hands-on experiential learning.

Target Audience

The course targets ABE students who possess foundational knowledge of genetics and demonstrate a preference for inquiry-based learning. These students are highly engaged by real-world applications of genetics, such as exploring genetic disorders or ethical dilemmas surrounding genetic technologies. However, they require structured guidance to build research and problem-solving skills effectively. Many also need support in collaborating with peers during group tasks, particularly in an online environment where synchronous interactions are the primary mode of engagement.

Learning Objectives

The course is designed to enable students to:

- *Analyze genetic mechanisms*, including both classical (Mendelian) and modern (chromosomal) understandings of inheritance, along with their societal implications. (**BI30-GB1**)
- *Develop problem-solving skill*s to address real-world issues, such as genetic disorders and ethical considerations in genetic technologies.
- *Collaborate effectively* to research, discuss, and propose solutions to complex genetic problems.

These objectives align well with the course's emphasis on skill development and real-world relevance but require careful instructional design to ensure students are adequately supported in achieving them.

Constraints

Several constraints must be addressed to optimize course delivery and outcomes:

- *Limited Access to Physical Labs*: The absence of physical labs limits opportunities for tactile learning, making the use of virtual lab simulations and digital tools essential for replicating hands-on experiences.
- *Diverse Research and Collaboration Skills*: Students come with varying levels of proficiency in independent research and group collaboration, especially ABE students who have been away from the classroom for various number of years. This diversity can impact the effectiveness of inquiry-based and team-oriented activities.
- *Online Synchronous Format:* The fully online format requires interactive problem-solving activities to maintain engagement, but these must be carefully designed to accommodate technical limitations and diverse learning preferences.

Opportunities for Enhancement

To address these challenges, the course can be enhanced by integrating scaffolded research tasks, guided group projects, and interactive virtual labs. Structured support mechanisms, such as templates for research and clear guidelines for collaborative assignments, can help bridge skill gaps. Leveraging synchronous tools like breakout rooms, virtual whiteboards, and real-time polling can foster more dynamic problem-solving sessions. Additionally, incorporating diverse examples of genetic applications, from medical case studies to ethical debates, can enhance relevance and engagement, ensuring alignment with the course's inquiry-based approach and learning objectives.

DESIGN

The design phase of the genetics unit in the Biology 30 course focuses on creating an engaging, problem-based learning experience that emphasizes collaboration, critical thinking, and real-world applications. This approach aligns with the course objectives and addresses the identified constraints by leveraging virtual tools and scaffolded support to foster meaningful student engagement.

Instructional Strategy

To facilitate deeper learning, the course will employ a problem-based learning (PBL) strategy centered on real-world genetic disorders and their societal implications. Students will work in small, collaborative groups to investigate open-ended scenarios, such as the ethical implications of gene editing technologies like CRISPR or the societal impact of widespread genetic screening programs. Each group will analyze genetic concepts, research societal factors, and propose evidence-based solutions to these complex problems. The collaborative structure will encourage peer learning while fostering critical discussion and teamwork.

Learning Activities

Learning activities are designed to engage students actively and develop their analytical and problem-solving skills:

- *Problem Exploration*: Students will be presented with open-ended scenarios requiring them to analyze genetic mechanisms, societal impacts, and ethical considerations. Scenarios will be tailored to incorporate foundational knowledge while challenging students to synthesize new information.
- *Research and Discussions*: Guided research activities will encourage students to gather relevant information from credible databases and

curated resources. Instructors will facilitate discussions to help students interpret findings, connect concepts, and collaboratively develop solutions.

- *Virtual Simulations*: Students will engage with virtual simulations to model genetic mechanisms, such as inheritance patterns or mutations, and explore ethical scenarios. These simulations will provide experiential learning opportunities in a virtual format, compensating for the lack of physical labs.

Assessment Methods

To ensure alignment with the learning objectives, a combination of formative and summative assessments will be employed:

- *Formative Assessments*: Checkpoints will be integrated throughout the module, including group discussions, progress updates, and research plans, allowing instructors to provide ongoing feedback.
- *Summative Assessments*: Students will present their proposed solutions through group presentations or detailed written reports. Assessments will evaluate their ability to analyze genetic mechanisms, consider societal implications, and justify their solutions effectively. Rubrics will guide the evaluation of problem analysis, critical thinking, solution development, and teamwork.

Resources Required

The following resources will support the instructional strategy and learning activities:

- *Virtual Collaboration Tools*: Platforms like Zoom breakout rooms for group discussions and shared documents (e.g., Google Docs) for collaborative research and writing.

- *Research Databases and Curated Resources*: Access to scientific journals, case studies, and pre-selected resources on genetic disorders and technologies to streamline research efforts.
- *Simulations and Interactive Tools*: Virtual genetics labs and ethical dilemma simulations to provide hands-on learning experiences in a digital environment.
- *Assessment Rubrics*: Detailed rubrics for formative and summative assessments to ensure transparency in evaluation and guide student efforts.

DEVELOPMENT

The development phase focuses on creating the instructional materials, scaffolding resources, and technological tools needed to implement the genetics unit effectively. Each component is designed to provide a comprehensive and engaging learning experience, emphasizing critical thinking, collaboration, and real-world applications of genetic concepts.

Content Creation

Realistic, open-ended problems are central to this unit, encouraging students to explore genetic disorders and their societal implications. For example, one case study may involve a family deciding whether to pursue genetic screening for a hereditary disorder, requiring students to analyze inheritance patterns, evaluate the accuracy and limitations of screening technologies, and consider ethical dilemmas, such as genetic privacy and potential discrimination. Other problems may focus on broader societal issues, such as the ethical use of CRISPR technology or public policies on genetic testing. Each problem will be accompanied by guiding questions to help students approach their analysis systematically, ensuring alignment with the learning objectives.

Instructional materials will include comprehensive guides that provide background information on genetic mechanisms, examples of real-world genetic disorders, and an overview of key ethical and societal challenges in genetics. These resources will be designed to support independent research while encouraging students to connect theoretical knowledge with practical applications.

Scaffolding Materials

To ensure students are equipped to tackle complex problems, scaffolding materials will focus on building foundational skills in critical thinking and collaborative problem-solving:

- *Critical Thinking Tutorials*: Short video or text-based tutorials will guide students through the process of analyzing genetic data, evaluating conflicting evidence, and formulating evidence-based arguments.
- *Collaborative Problem-Solving Guides*: Resources will outline strategies for effective teamwork, including setting group goals, dividing tasks, and resolving conflicts.
- *Sample Discussions*: Pre-recorded discussions or text-based scenarios will illustrate ethical and societal debates in genetics, such as balancing scientific advancements with moral considerations. These examples will model how students can articulate their ideas and engage in respectful, constructive dialogue.

Technological Tools

To facilitate collaboration and streamline the problem-solving process, technological tools will be integrated into the unit design:

- *Collaborative Platforms*: Tools like Google Workspace (Docs, Slides) and Zoom breakout rooms will enable synchronous and asynchronous group

work. These platforms will allow students to brainstorm, document research, and prepare presentations.

- *Research and Solution Templates*: Customizable templates will be provided for documenting research findings, ethical considerations, and proposed solutions. These templates will help students organize their thoughts and ensure their work aligns with assessment criteria.
- *Interactive Simulations*: Virtual tools, such as Labster or Learn Genetics simulations, will be embedded into the course to model genetic mechanisms and provide experiential learning opportunities. For example, students can simulate genetic screening processes or explore the effects of specific mutations.

IMPLEMENTATION

The implementation phase ensures the successful rollout of the genetics unit in the Biology 30 course by addressing key components such as pilot testing, instructor training, student orientation, and resource distribution. This phase is designed to identify potential challenges, prepare stakeholders, and provide the tools and resources needed to facilitate a seamless learning experience.

Pilot Testing

A pilot test will be conducted with a small group of students to evaluate the problem scenarios, instructional materials, and virtual collaboration tools. This initial trial will assess student engagement, the clarity of instructions, and the feasibility of proposed activities within the online synchronous format. Feedback will be collected through surveys and instructor observations to identify areas for improvement. Additionally, the effectiveness of collaborative platforms, such as Zoom breakout rooms and shared documents, will be tested to ensure they support group work and problem-solving activities effectively.

Instructor Training

Instructors will receive targeted training to prepare them for facilitating problem-based learning in an online environment. Training sessions will focus on strategies for guiding discussions, encouraging deeper inquiry, and scaffolding complex tasks. Instructors will also be introduced to the technological tools used in the unit, including virtual labs, collaboration platforms, and research databases. This preparation ensures that instructors are equipped to manage virtual interactions, support student learning, and address technical challenges.

Student Orientation

A dedicated orientation session will introduce students to the problem-based learning approach, setting clear expectations for participation and collaboration. This session will provide an overview of the unit's structure, including how to engage with the problem scenarios and use the tools and resources provided. Tutorials on accessing virtual labs, navigating research databases, and utilizing collaborative tools will ensure that students feel confident and prepared to engage in the course activities.

Resource Distribution

To support both instructors and students, all necessary resources will be distributed before the start of the unit. These resources include access to the problem scenarios, curated research databases, instructional guides, and templates for documenting research and solutions. Virtual collaboration tools will be pre-configured to allow seamless group work, and links to tutorials and support documents will be readily accessible. Clear communication regarding how and when to access these materials will ensure smooth integration into the course.

EVALUATION

The evaluation phase ensures that the genetics unit in the Biology 30 course meets its learning objectives and provides meaningful, engaging experiences for students. By incorporating both formative and summative evaluations, as well as strategies for continuous improvement, this phase enables instructors to assess the effectiveness of the instructional design and identify areas for refinement.

Formative Evaluation

Formative evaluation will be conducted throughout the unit to gather real-time feedback and make necessary adjustments. Feedback from students and instructors will be collected during each problem cycle through quick surveys, reflective discussions, and instructor observations. These insights will help refine activities to ensure clarity, engagement, and alignment with learning objectives. Group dynamics and research progress will be monitored through regular check-ins, where instructors can provide targeted support or address challenges that arise. This iterative process ensures that any issues are resolved promptly, allowing for a smoother learning experience.

Summative Evaluation

Summative evaluation will focus on assessing the final outcomes of the unit. Students' solutions, presentations, and written reports will be evaluated using detailed rubrics designed to measure their analytical abilities, problem-solving skills, and the quality of their proposed solutions. Additionally, qualitative feedback will be collected from both students and instructors at the end of the unit to gauge overall satisfaction, perceived learning outcomes, and the effectiveness of the instructional design. This feedback will provide a comprehensive understanding of the unit's impact and areas for improvement.

Continuous Improvement

Insights from both formative and summative evaluations will inform a continuous improvement process, ensuring that the genetics unit evolves with each iteration. Feedback will be used to refine problem scenarios, making them more relevant and engaging. Instructional strategies will be adjusted to better support diverse learning needs, and resources, such as tutorials and templates, will be enhanced based on user experiences. By implementing these improvements, the course will remain dynamic, addressing emerging challenges and aligning more closely with the goals of inquiry-based learning.

This comprehensive evaluation approach ensures that the genetics unit not only meets its immediate objectives but also fosters ongoing enhancement, creating a more effective and engaging learning experience for future students.

CONCLUSION

This needs analysis for the Biology 30 genetics unit emphasizes the importance of aligning course design with ABE students' needs and objectives. The unit focuses on developing skills in analyzing genetic mechanisms, exploring societal implications, and solving real-world problems using a problem-based learning (PBL) approach in a synchronous online format.

Key challenges include varying student research and collaboration skills, the complexity of genetic concepts, and reliance on virtual resources. However, the course is supported by robust tools like simulations, collaborative platforms, and scaffolding materials. Stakeholder feedback highlights the need for clear guidance, engaging problem scenarios, and interactive opportunities to enhance learning.

Addressing these challenges ensures the course meets its objectives, providing students with the skills to connect genetics to real-world applications.

The findings from this analysis will guide refinements to instructional design, enhancing engagement and fostering meaningful learning outcomes.

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