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Techniques and Tools

for Diagnosing Students at Risk in STEM Education

with a Focus on Sustainable Development

Introduction

This guide is designed to help educators identify students at risk of disengaging or dropping out of STEM subjects (particularly mathematics) and provide strategies to re-engage them through the use of DESMOS© and mini-PBL (Project-Based Learning) projects. The goal is to integrate Education for Sustainable Development (ESD) into STEM classes, making the content more relevant and engaging for students.

1. Student Student at Risk in Higher Education Institutions (HEIs)

A student at risk refers to an individual enrolled in a higher education program who faces academic, socio-economic, psychological, or circumstantial challenges that significantly hinder their ability to progress, succeed, or complete their studies. These students are identified through measurable indicators that predict a heightened likelihood of academic underperformance, disengagement, or dropout without targeted institutional intervention.

Identifying students at risk in higher education institutions (HEIs) serves multiple strategic, ethical, and operational objectives. These goals aim to enhance student success, institutional effectiveness, and equity while addressing systemic barriers to retention and graduation. Below are the key objectives:

a. Improve Retention and Reduce Dropout Rates

- Primary Goal: Prevent premature student departure by intervening early to address academic, personal, or financial challenges.
- Impact: Higher retention rates improve institutional outcomes, reputation, and resource efficiency.

b. Promote Academic Success

- Targeted Support: Provide tailored academic resources (e.g., tutoring, study skills workshops) to help students meet program requirements.
- Progression: Ensure students stay on track to graduate by addressing knowledge gaps or poor performance.

c. Enhance Equity and Access

- Address Systemic Barriers: Identify and support students from underrepresented groups (e.g., low-income, first-generation, or marginalized communities) who may face disproportionate risks.
- Close Achievement Gaps: Mitigate disparities in retention and graduation rates across demographic groups.

d. Support Student Well-Being

- Holistic Care: Connect students with mental health services, financial aid, or counseling to address non-academic challenges (e.g., stress, housing insecurity).
- Prevent Burnout: Foster resilience and work-life balance through proactive interventions.

By prioritizing the identification of at-risk students, HEIs can:

- Create equitable opportunities for success.
- Strengthen institutional resilience and adaptability.
- Build lifelong relationships with alumni.
- Contribute to societal and economic development through a skilled workforce.

In essence, the objectives blend student welfare, institutional accountability, and social responsibility, ensuring education remains a transformative and accessible experience.

Higher Education Institutions (HEIs) face significant challenges in effectively identifying, supporting, and retaining students at risk. These obstacles stem from systemic, operational, cultural, and resource-related limitations. Below are the main challenges and their implications.

2. Identifying Students at Risk

Key Indicators of Students at Risk

- **Academic Performance**: Consistently low grades or a sudden drop in performance.
- **Attendance**: Frequent absences or tardiness.
- **Participation**: Lack of engagement in class discussions or activities.
- **Behavioral Changes**: Signs of disinterest, frustration, or lack of motivation.
- **Social Isolation**: Withdrawal from peer interactions or group work.
- **Feedback**: Negative or indifferent responses to feedback or encouragement.

Diagnostic Tools

- **Formative Assessments**: Use quizzes, polls, and exit tickets to gauge understanding and engagement.

- **Learning Analytics**: Track student progress and participation in digital tools like Desmos.
- **Surveys and Questionnaires**: Collect student feedback on their interest, challenges, and perceptions of the subject.
- **Observation Checklists**: Monitor student behavior, participation, and interaction during class activities.
- **Peer and Self-Assessments**: Encourage students to reflect on their own learning and provide feedback on group dynamics.

3. Techniques to Re-engage Students

A. Contextualizing Content with Sustainable Development Goals (SDGs)

- **Relevance**: Connect mathematical concepts to real-world issues like climate change, renewable energy, or poverty reduction.
- **Mini-PBL Projects**: Design short, impactful projects that require students to apply STEM skills to solve sustainability challenges.
    - Example: Use Desmos to model the growth of renewable energy adoption and predict its impact on carbon emissions.

B. Leveraging Desmos for Engagement

- **Interactive Visualizations**: Use Desmos to create dynamic, visual representations of mathematical concepts.
- **Gamification**: Incorporate game-like elements in Desmos activities to make learning more engaging.
- **Collaborative Learning**: Encourage students to work together on Desmos activities, fostering peer support and collaboration.

C. Building a Supportive Learning Environment

- **Personalized Feedback**: Provide constructive, specific feedback that highlights strengths and areas for improvement.
- **Mentorship**: Pair at-risk students with peers or mentors who can offer academic and emotional support.
- **Growth Mindset**: Encourage a growth mindset by celebrating effort and progress rather than just outcomes.

D. Incorporating Student Voice and Choice

- **Project Topics**: Allow students to choose mini-PBL topics that align with their interests and the SDGs.
- **Flexible Deadlines**: Offer flexibility in deadlines to reduce stress and accommodate individual learning paces.
- **Reflection Opportunities**: Provide regular opportunities for students to reflect on their learning and set personal goals.

4. Tools for Monitoring and Intervention

A. Digital Tools

- **Desmos Activity Builder**: Track student progress and engagement in real-time.
- **Learning Management Systems (LMS)**: Use platforms like Moodle or Google Classroom to monitor participation and performance.
- **Data Dashboards**: Visualize student data to identify trends and patterns.

B. Communication Tools

- **Parent-Teacher Communication Apps**: Keep parents informed and involved in their child's progress.
- **Student Check-ins**: Schedule regular one-on-one meetings to discuss challenges and goals.

C. Intervention Strategies

- **Early Warning Systems**: Use data to identify at-risk students early and implement targeted interventions.
- **Differentiated Instruction**: Adapt teaching methods to meet the diverse needs of students.
- **Peer Tutoring**: Establish peer tutoring programs to provide additional support.

5. Evaluation and Continuous Improvement

A. Student Feedback

- Collect feedback on the mini-PBL projects and Desmos activities to identify what worked and what can be improved.
- Use surveys, focus groups, or reflection journals to gather insights.

B. Teacher Reflection

- Reflect on the effectiveness of the strategies and tools used.

- Share best practices and lessons learned with colleagues.

C. Data-Driven Adjustments

- Use data from formative assessments, Desmos activities, and other tools to refine future projects and interventions.
- Continuously adapt the approach based on student needs and feedback.

Conclusion

By integrating Education for Sustainable Development into STEM classes through mini-PBL projects and tools like Desmos, educators can create a more engaging and relevant learning experience. This guide provides a framework for identifying at-risk students and implementing strategies to re-engage them, ultimately fostering a deeper connection to STEM subjects and the principles of sustainability.

Appendices: Surveys and Questionnaires for Collecting Student Feedback

The following appendices include tools for gathering information about students' interests, challenges, and perceptions regarding STEM subjects (especially mathematics) and their connection to the Education for Sustainable Development (ESD) approach. These surveys and questionnaires can be used before, during, and after the implementation of mini-PBLs and Desmos activities.

Appendix 1: Interests and Motivations Survey

Objective: Identify students' interests and motivations toward mathematics and STEM subjects, as well as their connection to sustainability topics.

1. **Questions**:
    - What topics related to mathematics or science interest you the most? (E.g., algebra, geometry, statistics, renewable energy, climate change, etc.).
    - How do you feel about studying mathematics? (Scale of 1 to 5, where 1 is "very boring" and 5 is "very interesting").
    - Do you think mathematics can help solve real-world problems, such as climate change or poverty? (Yes/No/I don’t know).
    - Would you like to work on projects that connect mathematics with topics like sustainability or the environment? (Yes/No/I don’t know).
    - What type of activities would you like to do in class to learn mathematics? (E.g., projects, games, use of technology, etc.).
2. **Use**: This survey can be administered at the beginning of the course or before starting a mini-PBL to tailor projects to students' interests.

Appendix 2: Challenges and Difficulties Questionnaire

Objective: Identify areas where students face the most difficulties and how these affect their motivation.

1. **Questions**:
    - Which mathematics topics do you find the most difficult to understand? (E.g., equations, graphs, statistics, etc.).
    - What do you think would help you overcome these difficulties? (E.g., more explanations, practical exercises, group work, etc.).
    - Do you feel comfortable using digital tools like Desmos to learn mathematics? (Yes/No/I don’t know).
    - How do you feel about working in groups? (Scale of 1 to 5, where 1 is "very uncomfortable" and 5 is "very comfortable").
    - Have you considered dropping mathematics or any STEM subject? (Yes/No). If yes, why?
2. **Use**: This questionnaire can be administered during the course to identify at-risk students and provide them with personalized support.

Appendix 3: Perception Survey on Education for Sustainable Development (ESD)

Objective: Assess students' perceptions of integrating sustainability into mathematics or STEM classes.

1. **Questions**:
    - Do you think it is important to learn about sustainability in mathematics or science classes? (Yes/No/I don’t know).
    - Do you find it useful to connect mathematics content with real-world problems like climate change or renewable energy? (Yes/No/I don’t know).
    - Do you think projects like mini-PBLs help you better understand mathematical concepts? (Yes/No/I don’t know).
    - How do you feel about using tools like Desmos to work on sustainability projects? (Scale of 1 to 5, where 1 is "very negative" and 5 is "very positive").
    - What suggestions do you have to improve the connection between mathematics and sustainability in class?
2. **Use**: This survey can be administered after a mini-PBL or Desmos activity to evaluate the effectiveness of the ESD approach.

Appendix 4: Satisfaction and Engagement Survey

Objective: Measure students' level of satisfaction and engagement with the activities carried out.

1. **Questions**:
    - How would you rate your experience with mini-PBLs and Desmos activities? (Scale of 1 to 5, where 1 is "very poor" and 5 is "very good").
    - Did you feel motivated working on projects that connect mathematics with sustainability? (Yes/No/I don’t know).
    - What did you like most about the activities?
    - What did you like least or find most challenging?
    - Do you think these activities helped you better understand mathematical concepts? (Yes/No/I don’t know).
    - Would you recommend these types of activities to other students? (Yes/No).
2. **Use**: This survey can be administered at the end of a project or activity to gather feedback and improve future implementations.

Appendix 5: Student Reflection Template

Objective: Encourage students to reflect on their learning and engagement.

1. **Questions**:
    - What did you learn during this project or activity?
    - How did you feel working in a team or individually?
    - What challenges did you face, and how did you overcome them?
    - How do you think this project helped you understand the importance of sustainability?
    - What would you change or improve for future activities?
2. **Use**: This template can be used as a closing activity after each mini-PBL or Desmos activity.
