DESIGNING PRINCIPLES AND GUIDELINES FOR A PEDAGOGICAL FRAMEWORK OF STEM LEARNING THROUGH MOBILE SERIOUS GAMES

Ignace M KASIAMA[1]; Laurence CAPUS[2]

UNIVERSTE LAVAL, QUEBEC, CANADA

March 25, 2023

[1] Department of Educational Technology, Laval University, Quebec, Canada
[2] Department of Computer Science and Software Engineering, Laval University, Quebec, Canada

UNIVERSITÉ LAVAL

TABLE OF CONTENTS

UNIVERSITÉ LAVAL

1. OVERVIEW

THE URGENCY OF IMPROVING SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) LEARNING HAS BEEN INTERNATIONALLY RECOGNIZED.	IN PRACTICE, TEACHERS STRUGGLE AND LACK COHESIVE UNDERSTANDING OF STEM EDUCATION.	STUDENTS ARE MOST OF THE TIME DISINTERESTED IN SOME STEM SUBJECTS.
STUDENTS DO NOT UNDERSTAND HOW STEM KNOWLEDGE IS APPLIED TO REAL-WORLD PROBLEMS.	STUDENTS HAVE LITTLE OR NO UNDERSTANDING OF THE RELEVANT IDEAS IN THE INDIVIDUAL STEM DISCIPLINES.	THEREFORE, A STEM EDUCATION CONCEPTUAL FRAMEWORK IS NEEDED TO BUILD A RESEARCH AGENDA THAT WILL IN TURN INFORM STAKEHOLDERS TO REALIZE THE FULL POTENTIAL OF INTEGRATED STEM EDUCATION.

(Markham, Larmer, & Ravitz, (2003)   (Todd, 2016)
 Tasiopoulou et al. (2022)

2. PRESENTATION GOAL

We present principles and guidelines for a pedagogical framework of STEM Learning through mobile serious games:

- Design principles based on the theoretical and empirical understanding of teaching and learning.

- Guidelines for applying these principles in a stem learning environment using mobile educational serious games.

3. APPROACH TO THE PEDAGOGY OF SERIOUS GAMES

The technological disruption that has taken place in today's societies has led to the need for an educational response that is coherent with a hyperconnected social reality in a permanent state of change. In this context:

- It becomes necessary to rethink educational processes in order to meet the challenge of training individuals capable of performing effectively as active and participatory citizens in a global society.

- Active and deep learning are essential to achieve not only a transfer of knowledge, but an optimal education experience

- An educational game, becomes an activity that promotes a state of immersion and involvement, and of transformation to encourage students to engage with their learning activities.

- The game-based learning approach is linked to the work of Prensky as a pedagogical strategy to foster student engagement in conjunction with serious learning and entertainment in a new environment, where positive emotion is harnessed as a motivational element in learning.

Fernández-Sánchez, M.R.; González-Fernández, A.; Acevedo-Borrega, J. (2023)
Prensky, M. (2001)

4. MOBILE TECHNOLOGY IN SERIOUS GAME

❖ The following characteristics are recommended for the incorporation of mobile learning into an education learning environment:

Real world relevance	Use mobile learning in authentic contexts
Mobile contexts	Use mobile learning in contexts where learners are mobile.
Explore	Provide time for exploration of mobile technologies
Blended	Blend mobile and non mobile technologies
Whenever	Use mobile learning spontaneously

Anthony Herrington, Jan Herrington and Jessica Mantei (2009)

4. MOBILE TECHNOLOGY IN SERIOUS GAME - SUITE

Wherever	Use mobile learning in nontraditional learning spaces
Whomsoever	Use mobile learning both individually and collaboratively
Affordances	Exploit the affordances of mobile technologies
Personalise	Employ the learners' own mobile devices
Mediation	Use mobile learning to mediate knowledge construction.
Produce:	Use mobile learning to produce and consume knowledge.

Anthony Herrington, Jan Herrington and Jessica Mantei (2009)

5. WHAT IS STEM EDUCATION?

STEM education is the preparation for STEM fields and encouragement of STEM literacy.

A commonly accepted definition of STEM education is provided by Tsupros, Kohler, and Hallinen:

→ STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.

Tsupros, Kohler, and Hallinen (2009)

6. INTEGRATED STEM LEARNING

Pedagogical approaches that are best suited to facilitating STEM Integration:

Project Based Learning

A student-centered model that organizes learning around projects and includes complex tasks based on challenging questions anchored in real-world problems.

The essential features of PBL therefore include :

1. A central project
2. A constructivist focus on important knowledge and skills;
3. A driving activity in the form of a complex question, problem, or challenge;
4. A learner-driven investigation guided by the teacher; and
5. A real-world project that is authentic to the learner

(Markham, Larmer, & Ravitz, (2003)
Tasiopoulou et al. (2022)

6. INTEGRATED STEM LEARNING - SUITE

Pedagogical approaches that are best suited to facilitating STEM Integration:

Mobile Educational Serious Game

1. Digital games → scientific concept

2. Digital games → meaningful gam- ing experience

3. Digital games → interest in STEM

4. Scientific concepts → interest in STEM

5. Meaningful gaming experience → interest in STEM

Wu Y, Anderson, (2015)
Ball C, Huang K, Cotten SR, Rikard RV (2018)
Martin-Hansen L. (2018)

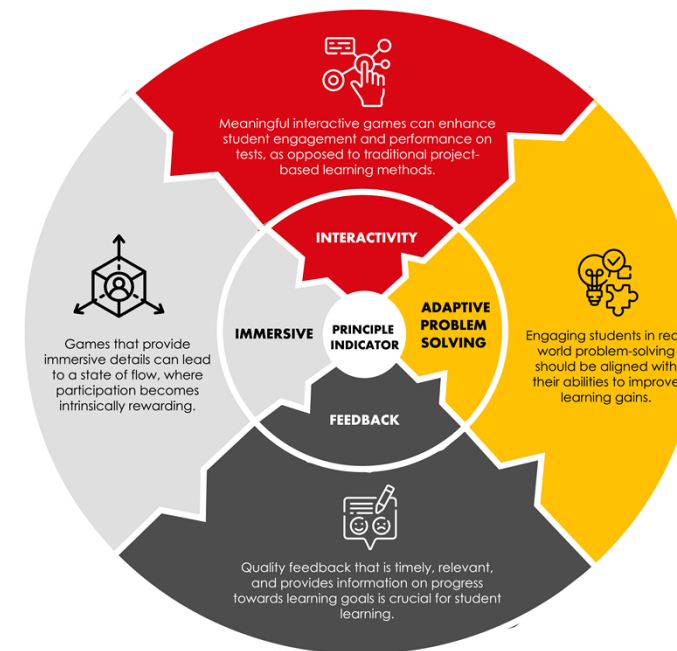Roberts T., al (2018)

UNIVERSITÉ LAVAL

7. DESIGN PRINCIPLES AND GUIDELINES OF STEM LEARNING THROUGH MOBILE SERIOUS GAMES

- Using the Pedagogical Framework for STEM Learning and **Design Principles** in the development of educational serious games can provide students with a more engaging and effective learning experience that helps them develop a deeper understanding of STEM concepts.

- As a result, it can help address the challenge of students having little or no understanding of the relevant ideas in individual STEM disciplines and can promote increased interest and participation in STEM fields.

UNIVERSITÉ
LAVAL
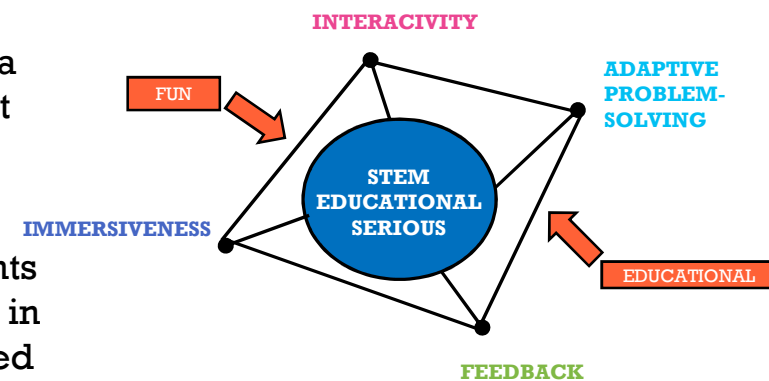
RESEARCH FINDINGS AS OUTPUT FOR STEM DIGITAL GAMES.

❖ Interactivity

❖ Adaptive Problem Solving

❖ Feedback

❖ Immersiveness

INTERACTIVITY
Meaningful interactive games can enhance student engagement and performance on tests, as opposed to traditional project-based learning methods.

ADAPTIVE PROBLEM SOLVING
Engaging students in real-world problem-solving should be aligned with their abilities to improve learning gains.

FEEDBACK
Quality feedback that is timely, relevant, and provides information on progress towards learning goals is crucial for student learning.

IMMERSIVE
Games that provide immersive details can lead to a state of flow, where participation becomes intrinsically rewarding.

PRINCIPLE INDICATOR

UNIVERSITÉ LAVAL

7.1. INTERACTIVITY

❖ Games that offer meaningful interactions.

❖ Interactivity in serious games refers to the degree to which a player can actively participate in the game, and affect the outcome or experience of the game through their actions and decisions.

❖ It involves the player's ability to control the game environment, interact with characters, and make choices that affect the game's progression.

UNIVERSITÉ
LAVAL

7.2. ADAPTIVE PROBLEM SOLVING

- Dynamically adjusting the difficulty of problems based on the player's performance and skill level.

- Adaptive problem solving in educational serious games refers to the ability of the game to dynamically adjust the difficulty and complexity of problems based on the player's performance and level of mastery.

- The game adapts to the player's skill level, providing challenges that are appropriately challenging but not too difficult, so as to keep the player engaged and motivated to learn.

7.3. FEEDBACK

- Provides players with information about their performance, progress, and areas for improvement, which is essential for effective learning outcomes.

- Feedback in educational serious games refers to the information provided to the player about their performance in the game, such as their progress, achievements, and areas for improvement.

- The feedback can be presented in various forms, including visual displays, audio cues, or text-based messages, and can be provided in real-time or at specific points in the game.

- Feedback is an essential element of educational serious games, as it helps players to understand their strengths and weaknesses, leading to more effective learning outcomes.

UNIVERSITÉ
LAVAL

7.4. IMMERSIVENESS

- Creating a realistic and engaging environment that captures the player's attention and involves them in the learning process.

- Immersiveness in educational serious games refers to the extent to which the game creates a realistic, engaging, and interactive environment that fully absorbs the player's attention and involves them in the learning process, often using elements such as high-quality graphics, sound effects, and virtual reality technologies.

8. ANTICIPATED OUTCOMES

❖ Validated Design Principles for Educational Games

❖ Series of Validated Educational Games

❖ Data Analysis Toolkit for Educational Game Research

WILL ALLOW US TO

❖ Positively influence the field of educational game design

❖ Positively influence educational game research models

❖ Positively influence the integration of educational games into curriculum

❖ Positively influence students' achievement in STEM areas

UNIVERSITÉ LAVAL

9. CONCLUSION

A body of knowledge of learning and teaching principles and strategies is urgently needed to inform teachers wishing to utilise innovative mobile technologies and also to inform the development of national policy and pedagogical approaches about emerging mobile devices.

Thank you