Chapter 14
Designing a Set of Web-Based Simulations to Facilitate STEAM Activities on How to Travel From Earth to Mars

Ilias Sitsanlis
1st General Lyceum of Alexandroupolis, Greece

Hariton M. Polatoglou
Aristotle University of Thessaloniki, Greece

ABSTRACT

In this chapter, the authors analyze a subject that is suitable for STEAM education and design a set of web-based simulations and material for blended learning to support STEAM activities on how to travel from Earth to Mars. Interplanetary travel involves astronomy, biology, and physics for science; technology to make it possible; engineering to optimize a possible solution; art to produce artwork based on the orbits of planets and boost creativity; and mathematics to solve the differential equations, obtain data, and perform data analysis to reach conclusions. Based on the ADDIE model, the presently related and available simulations were analyzed and based on that analysis a set of streamlined simulations are proposed, designed, developed, implemented, and evaluated. Similarly, a didactic sequence was implemented. The evaluation of the didactic sequence and the streamlined simulations by expert educators testifies that the proposed method to create STEAM inquiry and simulation-based activities is productive and can be used with a variety of interesting STEAM integration subjects.

INTRODUCTION

A lot of missions to study Mars have been accomplished, sparked by the human interest to study a planet close to Earth but so much different concerning the sustainability of life (Ezell, E, Ezell, L, 1984, Changela, H., at. al., 2021). Currently there are many active missions on Mars, like the Perseverance,

DOI: 10.4018/978-1-6684-3861-9.ch014

Opportunity, and many more are programmed for the near future (NASA, 2021). Additionally, a lot of interest and discussion is placed on the prospect of sending humans to Mars. The endeavor has many challenges and could be a rich source for STEAM integration subjects. Examples of such subjects can be a) how to sustain live during the travel or on Mars and b) which trajectory to choose for the travel. Concerning the latter little can be found in educational literature.

One can find some work on some aspects of planetary motions for university students placing emphasis on the mathematical aspects. For example, in the work of Youssef (Youssef, 2017) the mathematical foundation of the Hohmann transfer is presented. The work of Woolley and Whetsel (Woolley & Whetsel, 2013) presents a representation of the transfer trajectories and through that they study in detail the transfer process. On the educational side Yu, Sahami and Denn (Sahami & Denn, 2017) examine the perceptions of university students concerning the planetary orbits and propose ways to teach that subject. The work of Lyra (Lyra, 2020) presents a proposal for teaching the Kepler's 2nd Law by explaining the historical necessity of introducing the Law.

Due to the spatial and time scale of the planetary motion and the interplanetary travel its necessary in STEAM activities for the students to include simulations. On the internet one can find at least eleven simulations, each one of which simulates some aspects of the possible orbits of bodies under their mutual gravitational force. In the introduction three of them will be presented. The first one can be found is the Gravity and Orbit (Gravity and Orbits, 2021). One can select the mass of the star and the mass of the planet. Using the mouse one can change the magnitude and the direction of the planet's velocity vector and thus produce different orbits. It is difficult to obtain the period of an orbit and to precisely set the velocity vector.

The second one can be found in the site NASA (NASA, 2021) and is a 3D simulation of our planetary system by NASA. And the third one can be found in (Planetary Transfer Calculator, 2021), and it is a 3D application to calculate the transfer trajectory of a spacecraft from one planet to another, or from a planet to a natural satellite, alas with very little insight.

Motion of two bodies under their mutual gravitational force, although of great importance and interest is not simple to teach or include in STEAM activities and in practice it is customary to resort on assumptions which make the results easier to comprehend but on the other hand restricting the possibilities for an inquiry-based learning. It is obvious that the subject has many aspects and is suitable as a STEAM integration subject (Ozkan & Umdu Topsakal, 2021). The science part includes space science, astronomy, and physics. Engineering and Technology is necessary for the design and the optimization of the space travel and Mathematics for the possible orbits of two bodies due to their mutual gravitational force. Art is always important as can shape the artifacts needed for the endeavor, embody, and communicate ideas and boost creativity. The aim of this chapter is to propose, explore and evaluate a method to produce a streamlined set of web-based simulations and a didactic sequence to facilitate STEAM activities on interplanetary travel at the middle and high school level. Both the simulations and the didactic sequence are intended for blended learning and to be complementary to formal education.

MOTIVATION

The magnitudes on the astronomical scale are enormous compared to those on Earth. The human mind and especially of a child is very difficult to perceive such scales. At such scales it is impossible for students to make measurements and study the motions of the planets. For these scales we need tools such