Chapter 13
Developing and Applying the Law of Cosines:
Using Star Maps as a Context

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EXECUTIVE SUMMARY

In history, geometry was founded more as a practical endeavor than a theoretical one. Early developments of the branch portray philosophers' attempts to make sense of their surroundings, including the measurement of distances on earth and in space. Such a link between earth and space sciences and geometry motivated us to develop and implement a multidisciplinary lesson focusing on the conceptual understanding of the law of cosines in the context of astronomy. In our content specific STEAM lesson, the authors aimed to facilitate an understanding of the law of cosines in ninth grade students, and then apply the law in a star map task to find approximate distances between stars. The second part of the lesson also included the use of an instructional technology to support students' work with the star map task. In the conclusion, the authors discuss possible ways to improve the quality of their STEAM education efforts for the given context.

INTRODUCTION

As research indicates, students experience significant gains and achievement from interdisciplinary instructional approaches in developing mathematics and science content knowledge; as a result, STE(A)M Education has globally become the ultimate goal of educational programs (Bybee, 2010; Marginson, Tytler, Freeman, & Roberts, 2013; Morrison & McDuffie, 2009; Venville, Rennie, & Wallace, 2004). With an emphasis on creativity and artistic processes, STEAM Education is now defined as the intentional integration of concepts, practices, and design features of science, technology, engineering, art, and mathematics subjects (Bequette & Bequette, 2012; Gess, 2017). Yakman (2010) discusses how the application of STEAM Education, in the context of a classroom, occurs in five different levels: 1) Universal level, 2) Integrated level, 3) Multidisciplinary level, 4) Discipline Specific level, and 5) Content Specific level. In this chapter we define *Content Specific STEAM Education* as the detailed study of a content area with the integration of two or more STEAM disciplines, one of which is the main focus. In the first part of our lesson, ninth grade students were guided to collaboratively discover *the law of cosines*. Then they solved a mathematics problem dealing with *Earth and space sciences*. In the second part of our lesson, students used an applet built in a dynamic geometry environment. In other words, we aimed to integrate the disciplines of mathematics, science, and technology using *discovery learning* as the main instructional strategy.

The law of cosines can be called the extension of the Pythagorean Theorem for acute and obtuse triangles. Even though the concept of cosine was not developed during the Euclid's time, the Elements includes the same equation with different notations and representations. The law makes it possible to find an unknown angle or side when two sides and the angle between them are known or when three sides are known.

Since the law of cosines includes several notations and concepts, many learners find it difficult to retrieve it from their memory and use it when it is needed to solve a problem. There are strategies to reduce the learner's memory load for the distance formula and the law of cosines. For example, McMullin (2003) used computer algebra systems to reduce students' memory load while they were solving a mathematical problem using the law of cosines. Whereas instructional technology usage in his article might have enabled students to find the correct answer for the problem quite promptly, McMullin's approach does not guarantee students' conceptual understanding of the law. To be able to conceptually understand the law of cosines, we believe that students need to synthesize several connected terms and notions in trigonometry and geometry.

Another way to reduce memory load is to use discovery learning approaches that enable learners to analyze and synthesize laws from triangles through deductive