Educational Applications of Solving Sangaku Problems by the MNR Method with Maxima

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Abstract

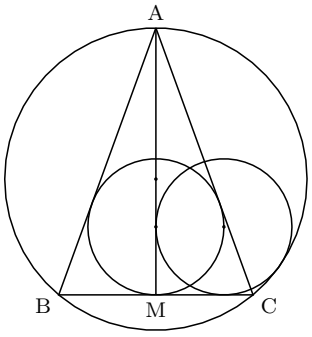
This paper explores the educational potential of solving traditional Japanese Sangaku problems using the MNR method in conjunction with the computer algebra system Maxima. Sangaku, geometric problems inscribed on wooden tablets during the Edo period, provide rich and challenging content for mathematical exploration. The MNR method allows for symbolic representation of geometric relationships within triangles, enabling efficient solution strategies through Maxima. By engaging students in the process of formulating problems, interpreting algebraic output, and visualizing geometric structures, this approach fosters deeper mathematical understanding and programming literacy. We demonstrate how this method can contribute to developing students' problem-solving skills, logical reasoning, and sustained interest in mathematics through culturally significant and intellectually stimulating content.

1 Introduction

Sangaku are wooden tablets inscribed with Japanese geometrical problems, offered at shrines and temples during the Edo period by people from all social classes. The MNR method is a symbolic approach for expressing geometric properties of a triangle as rational functions of m, n, and r, where m and n denote the tangents of the half-base angles, and r is the inradius([1]). Many Sangaku problems are highly challenging([2]). In this study, we explored the use of the MNR-based solutions to Sangaku problems as a means of mathematics and programming education.

2 Educational use of the MNR Method

Currently, approximately 820 Sangaku tablets remain in Japan. Among all the prefectures, Fukushima Prefecture has the largest number of surviving Sangaku. Figure 1 shows a problem inscribed on a Sangaku tablet at Tamura Taigen Shrine in Fukushima Prefecture.



Let r_1 be the radius of the incircle of the isosceles triangle ABC, where AB = AC, and let M be the midpoint of side BC. Consider a circle that is tangent to both segments AM and MC, and also internally tangent to the circumcircle of triangle ABC. Let the radius of this circle be r_2. Prove that $r_1 = r_2$.

Figure 1: Sangaku problem

Such problems are solved using the MNR method. In education for students, the process begins with simple geometry problems and follows the steps below.

1. Formulate equations based on the problem statement.
2. Use Maxima to solve the equations.
3. Modify or add expressions as needed while observing the results displayed on the screen.
4. Display diagrams when necessary.

The experiment was conducted at Fukushima National College of Technology, Japan. These colleges were established during Japan's period of rapid economic growth in the 1960s to train engineers. Students enter at the age of 15 or 16, the equivalent of the first year of senior high school in Japan, and study for a minimum of five years, graduating at what corresponds to the second year of university. The participants in this study were second-year students in the Department of Electrical Engineering.

3 Conclusion

The MNR method is expected to significantly enhance students' mathematical and programming abilities. Moreover, although solving Sangaku problems requires substantial knowledge and computational skill, working through these challenges independently fosters deeper interest, curiosity, and sustained engagement. Such experiences meaningfully contribute to the development of problem-solving skills and help cultivate a proactive attitude toward learning mathematics.

References

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