

Integration of Computer Algebra Systems and AI in HTML-based Mathematics Materials using KeTCindyJS

Masaki Suzuki

National Institute of Technology, Numazu College
email.m-suzuki@numazu-ct.ac.jp

Key words: *KeTCindyJS; KeTCindyChatBot; Maxima; Algebrite; Nerdamer;*

1 Introduction

The author has developed HTML-based teaching materials using KeTCindyJS, and in 2025 demonstrated that integrating KeTCindyJS with Maxima enables mathematically accurate and visually clear materials based on symbolic computation. However, this approach requires pre-computation in a local environment and is limited to predefined functions, restricting flexible interaction in web browsers. To address this issue, Algebrite, which enables symbolic computation within a browser, is introduced to construct an environment that supports arbitrary functions and equations. In addition, to reduce the difficulty of developing teaching materials using CindyScript, we are developing KeTCindyChatBot, and, as an application of the materials, an expression input/output system equipped with an automatic grading function using Nerdamer.

2 Development of Teaching Materials

By integrating KeTCindyJS with Algebrite, we enabled the development of HTML-based teaching materials that allow symbolic computation in a web browser. Specifically, a button was implemented to insert a script that embeds Algebrite into HTML files, based on a method developed by Kitamoto (Yamaguchi University) (Fig. 1). This allows learners to input arbitrary functions and equations and perform symbolic operations interactively, thereby promoting exploratory learning. Figure 2 shows an example of teaching material for observing Taylor expansions. While the integration with Maxima was limited to predefined functions, the proposed environment allows learners to dynamically explore the behavior of arbitrary functions.

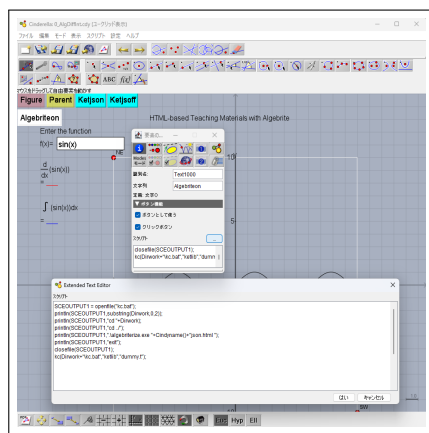


Figure 1: “Algebriteon” button

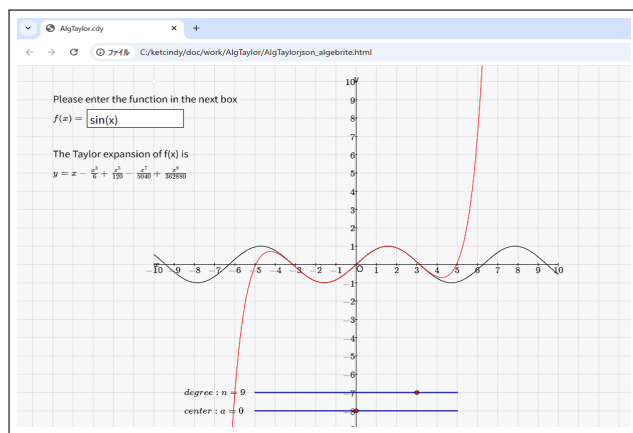


Figure 2: Taylor expansion

In addition, the author is developing KeTCindyChatBot to reduce the burden of teaching material creation. This system adopts a retrieval-augmented generation architecture based on a knowledge base constructed from KeTCindy references and existing teaching materials. By

generating minimal executable CindyScript in response to user input, the system improves development efficiency and lowers the barrier to creating teaching materials. A key feature of this system is its ability to generate code tailored to the syntax and functions specific to KeTCindy.

3 Application of Teaching Materials

As one application of the developed HTML-based teaching materials, the author, together with students, is developing an e-learning system. In this system, students work on exercises with the support of embedded HTML-based teaching materials (Fig. 3), and enter their answers as mathematical expressions in TeX format. The submitted expressions are then converted and processed using Nerdamer, a JavaScript-based computer algebra system. By leveraging symbolic computation, the system evaluates the equivalence between the submitted expressions and the expected answers (Fig. 4). Unlike conventional numerical evaluation, which checks only specific values, this approach enables structural comparison of algebraic expressions. As a result, mathematically equivalent expressions written in different forms can be correctly evaluated, providing a more flexible and accurate assessment. This functionality is particularly effective in classroom settings, where instructors need to quickly assess students' understanding. Immediate feedback can be provided based on the results of symbolic evaluation, allowing students to iteratively refine their answers.

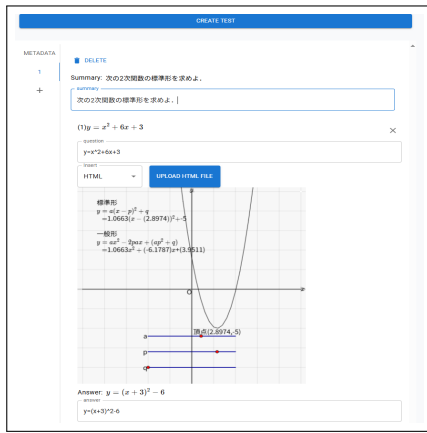


Figure 3: Inserting an HTML file



Figure 4: Automatic grading by Nerdamer

4 Conclusion and Future Work

An environment for developing HTML-based teaching materials was established by integrating KeTCindyJS with Algebrite and an AI support system (KeTCindyChatBot). By combining symbolic computation with interactive visualization, it becomes possible to create mathematically accurate and intuitive teaching materials. Furthermore, as an application of the developed materials, their use in an e-learning system is presented. In particular, automatic grading using Nerdamer is expected to enhance the assessment of students' understanding and improve feedback in classroom settings.

Future work includes improving the accuracy and functionality of KeTCindyChatBot, as well as evaluating its effectiveness through educational practice.

References

- [1] KeTCindy Home. <https://s-takato.github.io/ketcindyorg/indexe.html>
- [2] Shigeki Kobayashi, Setsuo Takato. Cooperation of KeTCindy and Computer Algebra System. Lecture Notes in Computer Science 9725, Springer, 351-358, 2016.
- [3] Setsuo Takato, Alasdair McAndrew, Jose A. Vallejo, Masataka Kaneko. Collaborative Use of KeTCindy and Free Computer Algebra Systems. Mathematics in Computer Science 11 3-4 , 503-514, 2017.