A CAS-based Pedagogical Approach for Teaching Laplace Transform to Electrical Engineering Students

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A CAS-based Pedagogical Approach for Teaching Laplace Transform to Electrical Engineering Students

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ABSTRACT
Laplace transform (LT) is a well-known and powerful tool in analysing and designing electrical systems, however, it is still a difficult subject for many students. LT is a computationally intense subject, and many students say that it was difficult to understand and master. Mathematica, Maple and MATLAB can be used to compute LT and Inverse LT; however, the results are hard to interpret. Manual calculation is a must to understand the dynamic behaviour of dynamic systems including electrical circuits and to be able to interpret the computer-generated results. The main goal of this research is to find out the difficulties that students face in understanding LT and to provide a pedagogical approach to enhance students' learning. The paper reviews the way LT is introduced in textbooks, related published research, students' prospects and evaluation to the proposed model. The paper also sheds light on the application of AI in LT active learning.

Keywords - Laplace transform, CAS-assisted, education, pedagogy, ChatGPT.

I. Background

There are many didactical approaches that can be implemented to enhance the students' learning. In (Brijlall and Maharaj, 2017) group work is implemented as a learning strategy. As group work is a collaborative learning method, the learning outcomes will be maximized. In (Karis et al., 2019) an electronic board simulator is used to enhance the learning. Problem solving mixed with lab exercises can lead to deep learning of this subject (Carstensen and Bernhard, 2009). In (Abou-Hayt and Dahl, 2024) the authors propose the use of MATLAB as a way of teaching LT, however relying only on computer simulations could not provide complete understanding as the results of the computer simulations need to be interpreted. In (Carstensen, 2013) the authors highlighted the importance of linking teaching LT along with lab exercise, as this will bridge the gap between mathematics and the real-world. The visual representation of LT could enhance students' understanding as mentioned in (Maljar and Stopjakova, 2021). It is highlighted that different teaching methodologies could be implemented, for example active learning methods such as, inquiry-based learning, flipped classroom learning, problem-based learning, methodology based on the analysis of errors. By examining literature, CAS-based teaching, active learning and practical applications should be implemented to enhance the learning process (Naandheny, Manjuri and Iyer, 2023). The paper proposes an integrated didactic model for teaching Laplace transform based on CAS-assisted (Computer Algebra System) learning.

II. Explanation

As a part of teaching Laplace transform to the electrical engineering students at DTU Engineering Technology, we found that the following questions need to be answered. What are the challenges that students face to learn Laplace transform? What are the required and expected outcomes from learning Laplace transform? and what are the best teaching strategies that should be implemented, and what are the required pre-knowledge?. The proposed approach for active teaching and learning can be generalized to other topics, for example, Fourier series. The proposed model integrates both hand calculations and CAS and links the physical system to s-domain as shown in Fig 1. The steps in

the proposed approach are as follows: Start with flipped classroom where the students have to question and find motivation, introduce the link between time-domain and s-domain, introduce student to MATLAB symbolic toolbox and perform hand calculation for simple cases, use CAS-assisted learn to solve complex problems. The teaching approach is based on linking LT to physical system, CAS-assisted learning and practical implementation.

An analysis of the students' evaluation of the course for a group of students has been made. After implementing the new approach, the students' mistakes decreased considerably, and students were able touse both hand calculations and computer simulation for comparison. As is the case with CAS-assisted learning, the students should be able to use AI tools, but they also should be able to interpret the results. AI can provide many advantages to teaching pedagogy, for example, personalized instructions, adaptive assessment, interactive environment, and real-time feedback (Opesemowo and Ndlovu, 2024). While AI can provide a new active learning experience it comes with challenges, especially, the accuracy and a balance between machines and humans is still needed. This issue will be improved in future by chatbots designers.

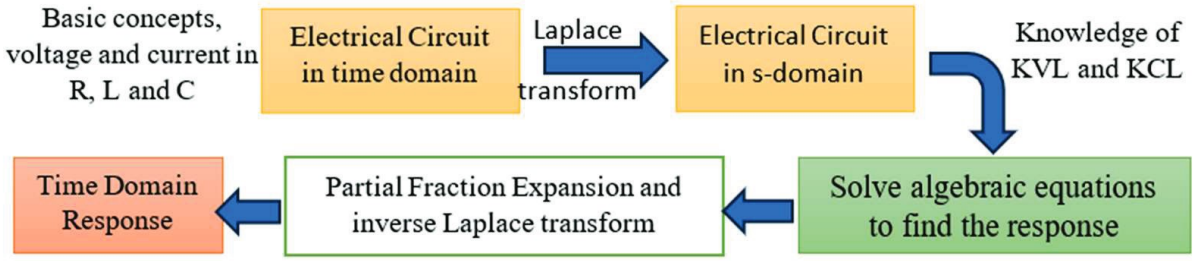

Figure 1. The proposed didactic model

III. Expected Outcome

The paper reviews the current teaching methods, and it is found that the lack of motivation and the tedious and complex calculation hinder the learning process. A balance between calculations by hand and CAS-assisted learning should be made to avoid repeating tedious mathematical calculations. Based on the students' evaluation the proposed didactic model was efficient and motivated the students. The application of AI in teaching and learning LT was examined, and it can be concluded that it can further enhance students' learning, however, there are still some challenges related to AI authenticity.

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