Case Study of an Online Course on *Introductory Mathematics for Artificial Intelligence**

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Abstract
Artificial Intelligence (AI) is one of the most crucial factor affecting future career choice of students. Accordingly, we offered students a semester-long Introductory Mathematics for Artificial Intelligence course. The course was developed to provide undergraduate students with various majors to navigate their career opportunities in AI-related jobs. This paper presents the newly published textbook and an online mathematics laboratory that integrated effective technology for this introductory course. In addition, we introduce a process-driven evaluation method based on the Problem/Project-Based Learning (PBL) report that worked well for this course. We also share trails of communications with our students and added the results of our students' performance analysis using principal component analyses (PCA) with the data generated from the class.

1. Introduction

Artificial intelligence (AI) is being actively used almost everywhere. For example, military, finance, medical, legal, and industrial sectors use AI, especially deep-learning and machine learning algorithms. Demand for AI experts has drastically increased. Many universities endeavor to educate students of diverse backgrounds (e.g., science, engineering, arts, social science, sports science, law, etc.) to understand and utilize AI algorithms to meet their fields' needs.

While it is difficult and meaningless to define using AI for any task in one word [10], it often requires an ability to process and predict using given data. In this process, various mathematical theories and

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techniques are used. It is not trivial to apply AI appropriately to solve problems without studying mathematics and understanding the principles of algorithms.

This study first developed a curriculum covering essential mathematics concepts needed for AI for university students of various majors. Then we offered a three credits course in the spring semester of 2020. Finally, we published a textbook *Introductory Mathematics for AI,* an e-book (https://buk.io/@kb5299). We also created and provided an online mathematics laboratory (http://matrix.skku.ac.kr/intro-math4ai/). The textbook and the laboratory are the novelty of our work.

Of course, there are online courses[‡] and books [5,26] on mathematics for artificial intelligence, machine learning, and data science. However, unlike these existing online courses and books, we needed a new curriculum that meets the following four conditions; First, it should be easy enough for all college freshmen to follow. In other words, it was necessary to carefully select the most of core contents so that students in any major could have a big pictue of mathematics used in artificial intelligence. This is because this course aims for equity in AI literacy[§]. Second, we hoped that the learning of mathematics should be core part of this curriculum over artificial intelligence in a convergence approach [11,31]. Third, the emphasis was placed on applying mathematical concepts through hands-on practice, rather than simply learning and solving problems. The paradigm of learning has shifted to one that can be applied rather than just knowing [18,27], and textbooks and materials should be able to support these things [24,30]. Therefore, it was hoped that the students would directly utilize the convergence of mathematics and artificial intelligence and contribute to making them into their own knowledge. Finally, it was our aim to provide an environment in which active interactions can occur in all these series of learning processes as is suggested in [3]. These are differences of our efforts from the existing online courses and books.

Due to the COVID-19 pandemic, we had to offer this course online. However, in general, online classes have several limitations. In particular, it is challenging to grasp students' learning process, induce rigorous thinking and learning through discussions, give fair evaluations, and design out-of-class activities [2,6,20]. In addition, we cannot emphasize enough that students need to adapt themselves to the educational paradigm shift, and we need to lead educational innovation in such a rapidly changing social environment [23].

To overcome these difficulties of online classes, the researchers made the following instructional design and conducted the classes accordingly. First, an environment was established to promote students' self-activities within and outside the class. To do this, we provided a new online mathematics laboratory, that was built with pre-coded Python-based SageMath cells. Students could practice what they learned by modifying the code quickly and trying various data analysis tasks in this online laboratory. Students had access to pre-recorded lectures in the university's Learning Management System (LMS) at least a week in advance of real-time streaming lectures to study the teaching material beforehand and ask any questions that arise during their studies. Additional live video streaming Office Hours (OH) were offered through Zoom or WebEx once or twice a week. The

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[‡] AI Mathematics - W3Schools. https://www.w3schools.com/ai/ai_mathematics.asp

Mathematics for Machine Learning. https://www.coursera.org/specializations/mathematics-machine-learning

[§] Artificial Intelligence for All: A Call for Equity in the Fourth Industrial Revolution.

https://ourworld.unu.edu/en/artificial-intelligence-for-all-a-call-for-equity-in-the-fourth-industrial-revolution
The Artificial Intelligence (AI) for K-12 initiative (AI4K12) https://ai4k12.org/