EDUCATION TO PREVENT HUMAN MECHANISATION IN A FACULTY OF INFORMATICS: DEVELOPING LEARNING MATERIALS TO IMPROVE STUDENTS' VERBAL COMMUNICATION SKILLS

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ABSTRACT

Although information technology (ICT) education is being strengthened based on the national context, there are reports suggesting a decline in young people's communication skills. This phenomenon can be attributed to the rapid development of informatisation, which includes the diversification and spread of information tools, as well as the prevalence of nonverbal communication, such as pictograms in social networking services. In addition, the COVID-19 pandemic has drastically reduced face-to-face communication opportunities, making interactive communication in on-demand classes challenging. Even in assignments and short tests completed during class, many instances of content being copied and pasted from the web or written in a disorganized manner have been observed. For instance, students entering ICT-related careers, particularly those graduating from the faculty of informatics, must possess the ability to communicate with engineers and clients while implementing ICT advance-ments. Alongside programming skills, strong communication abilities are essential. Moreover, the emergence of generative artificial intelligence (AI) tools, such as ChatGPT and Bing AI, has considerably diminished the opportunities for independent thinking. In the current era of enhanced ICT education, AI, and IoT, the Faculty of Informatics at the Kanagawa Institute of Technology has been engaged in discussions regard-ing learning materials that aim to strengthen students' ability to think and communicate in their own words, preventing the mechanisation of individuals. This paper presents the development and implementation of learning materials designed to enhance students' verbal communication skills through the description and re-production of mathematical graphs.

KEYWORDS

Information Education, Verbal Communication, Expressive Language Skills, University Students, Development of Teaching Materials

1. INTRODUCTION

Although information technology (ICT) education is being strengthened based on the national context[Strategic Headquarters 2017], there are reports suggesting a decline in young people's communication skills[Furlong 2006; Jenkins 2009]. This phenomenon can be attributed to the rapid development of informatisation, which includes the diversification and spread of information tools, as well as the prevalence of nonverbal communication, such as pictograms in social networking services. In addition, the COVID-19 pandemic has drastically reduced face-to-face communication opportunities, making inter-active communication in on-demand classes challenging. Even in assignments and short tests completed during class, many instances of content being copied and pasted from the web or written in a disorganized manner have been observed. For instance, students entering ICT-related careers, particularly those graduating from the faculty of informatics, must possess the ability to communicate with engineers and clients while implementing ICT advancements. Alongside programming skills, strong communication abilities are essential. Moreover, the emergence of generative artificial intelligence (AI) tools, such as ChatGPT[Lund 2023] and Bing AI, has considerably diminished the opportunities for independent thinking.

In the current era of enhanced ICT education, AI, and IoT, the Faculty of Informatics at the Kanagawa Institute of Technology has been engaged in discussions regarding learning materials that aim to strengthen students' ability to think and communicate in their own words, preventing the mechanisation of individuals. This paper presents the development and implementation of learning materials designed to enhance students' verbal communication skills through the description and reproduction of mathematical graphs.

2. VERBALISATION OF FUNCTION GRAPHS

In order to address concerns about the mechanization of individuals within the Faculty of Informatics, educational materials have been developed to improve students' verbal communication skills. One approach involved presenting function graphs to students and tasking them with describing the graph's shape using only words, without relying on mathematical formulas.

2.1 Verbalisation of Function Graphs

To facilitate the process, we created an Excel macro to generate graphs for seven types of functions: trigonometric (e.g., sine), exponential, logarithmic, polynomial (e.g., quadratic and cubic), irrational, and hyperbolic. A total of 100 function graphs were generated, randomly select-ed, and uploaded to the web. Students were then in-structed to write sentences that accurately conveyed the graphs, allowing others to reproduce them. This study included approximately 120 undergraduate students from the second to fourth years of an informatics, as well as 20 graduate students pursing a master's degree.

2.2 Examples of Results

An exponential function (Equation (1)) is depicted in the graph, along with excerpts from the descriptions (excerpts) provided by the students.

-Exponential function

$$y = a exp(bx + c) + d \quad \ldots\ldots\ldots\ldots (1)$$

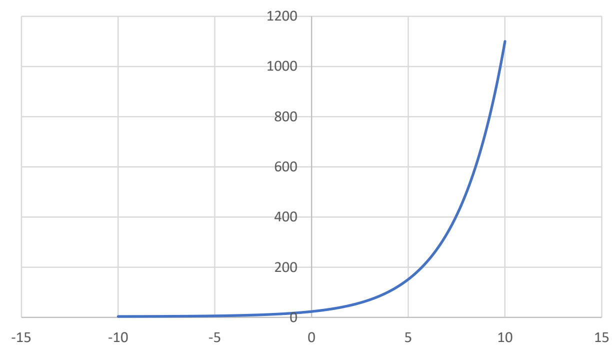

Figure 1. Example of a graph used to describe functions verbally

- Sample answer A: This graph consists of a single line that originates from the bottom left, extends almost straight across, and then sharply bends toward the top right.
- Sample answer B: The graph spans from −15 to 15 on the x axis and from 0 to 1200 on the y axis. From −10 to 0, the line remains almost straight along the x-axis direction and gradually moves upward on the y-axis. When x = 0, it curves up-ward until x = 5, aiming for an approximate y-axis value of 180. From there, it forms a curve directed towards (10, 1100).
- Sample answer C: The graph resembles the ascending part of a roller coaster ride. It is defined within a horizontal range of −15 to 15 and a vertical range of 0 to 1200. It starts at a horizontal value of −10 and a vertical value of 0. The gradient gradually increases to approximately −2.5 horizon-tally and passes

through the points (0,20). Then, the gradually becomes steeper, aligning with the point (5, 750). Next, at a vertical value of 400, the horizontal value is set to 7, and at 600, the graph passes through 8 horizontally. It continues with a horizontal value of 9 at a vertical value of 800, and at 1000, the horizontal value is 9.9. The graph concludes at a vertical value of 1100 and a horizontal value of 10.

- Sample answer D: The graph represents the exponential function, exp(x). It exhibits several characteristics. Firstly, for any x, its value is greater than 0, indicating that the graph lies above the x-axis. Secondly, as the x-axis value increases, the y-axis value also increases. Lastly, the y-axis value rises more rapidly as the x-axis value progresses towards the right. These three characteristics result in an initial depiction of a straight line, where the x-axis value re-mains relatively unchanged from −20 to 0. However, the x-axis value increases and approaches a positive value, the graph ascends rapidly towards the right.

2.3 Examples of Graphical Results from Descriptions

Examples of graphing results generated by four participants following the verbal descriptions provided by another participant as discussed in Section 2.2, are showcased. It is noteworthy that some of the sentences in the description could not be reproduced as graphs at all.

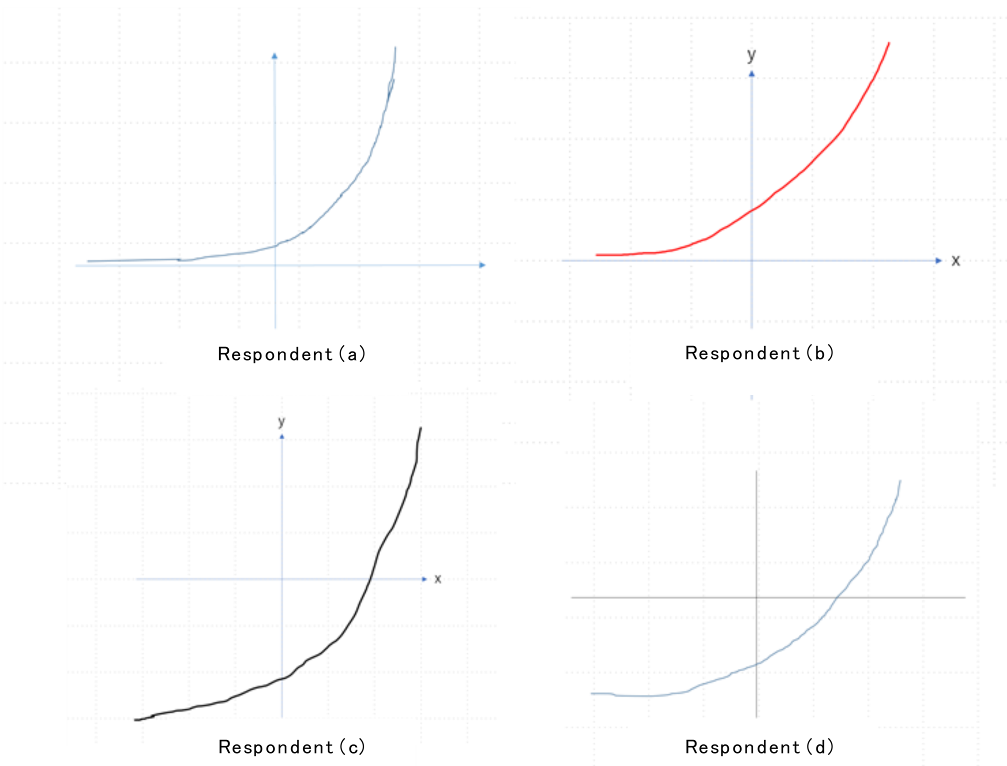

Figure 2. Example of a graph generated from a description

2.4 Analysis

The percentage of students who were able to provide accurate descriptions of a given graph was less than 10% in all sessions. Only approximately 20% of the sentences effectively conveyed the features of the graph. Our findings from multiple attempts to verify function graph descriptions, along with the challenges of verbalisation, are as follows.

In terms of mathematical thinking skills, students generally demonstrated an understanding of the formulas and functions represented in the graphs.

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Comprehension served as a means to assess whether students accurately understood the task.

Explanatory ability was used to evaluate students' capability to describe the graphs to others.

We also gauged the students' attitudes towards the task. Additionally, since there were no reference materials available on the web, the students had to rely on their own thinking.

In online classes, although concerns about instances of students copying others' answers have been raised, the nature of the verbalisation task with multiple answers, serves as a preventive measure against cheating and other dishonest behaviors.

The students received feedback from others regarding the level of difficulty and significance of communication skills, as well as the proficiency and adequacy of their own communication skills.

Challenges in the development of such teaching materials included the difficulty of drawing and evaluating graphs. In the subsequent sections, we provide a detailed description of the task assessment and propose an implementation scheme for creating graphs from descriptions as part of teaching materials.

3. ASSESSMENT OF COMMUNICATION SKILLS

Communication skills encompass the abilities to communicate (explain) and read (comprehend) information. Textual explanations of graphs were used to evaluate these skills. In addition, peer evaluation (mutual evaluation) was used for efficient assessment.

The participants were divided into groups of approximately five (n), and the illustrated procedure was employed to assess their expository and reading comprehension skills.

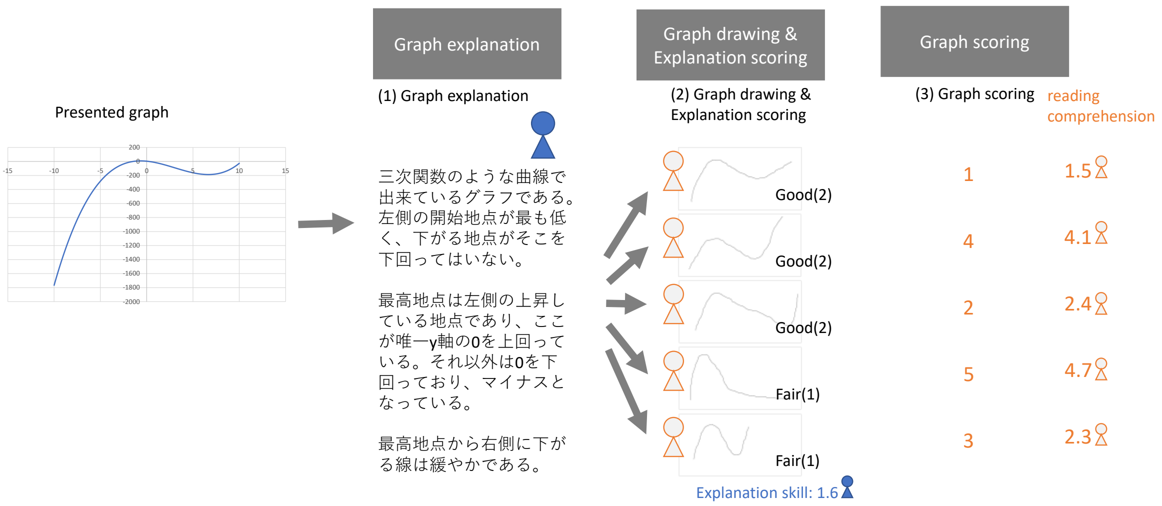

Figure 3. Example of the results obtained from the text-to-graph communication evaluation

Step 1: The participants per group described different graph descriptions.

Step 2: Based on the descriptions provided by the other group members ($n - 1$), each participant drew a graph and evaluated the understandability of the descriptions. The evaluation involved assigning a score of 2 for good understanding, 1 for poor understanding, or 0 for no understanding. The average score across the (n-1) persons was considered the score for explanatory power.

Step 3: The accuracy of the ($n - 1$) graph descriptions were ranked by all the participants, resulting in rankings for each case. The average ranking was used to determine the reading comprehension rank. Because an accurate graph could not be drawn if the explanation was difficult to understand, the reading comprehension was adjusted by assigning weights ac-cording to the explanatory power.

Step 4: By drawing graphs based on various explanations provided by others in step 2, participants were able to discern the differences comprehensive and unintelligible explanations. They also learned which features should be communicated and how to effectively convey them.

Step 5: Referring to the graph drawn based on the description provided in step 3, each participant assessed what was conveyed or omitted in their description. They also identified incorrect or lacking parts in the descriptions.

Step 6: In addition to the procedure of providing a graph, verbalising it, drawing it, and evaluating it, a re-verse procedure of providing an explanation of the graph, drawing it, verbalising it, and then evaluating it facilitated more precise evaluations of communication skills.

4. DEVELOPMENT OF EVALUATION APPLICATION

4.1 Functions

We developed an application to streamline the assessment of communication skills. The application consists of three screens, which aligns with the steps outlined in Section 3.

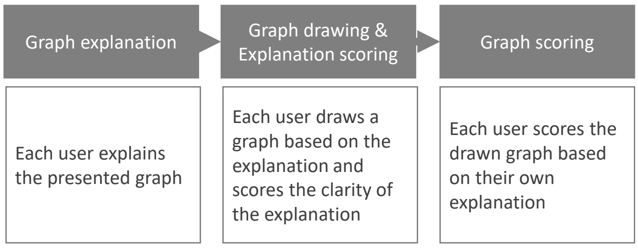

Figure 4. Functions of the application for assessing communication skills

Graph description. The application displays a graph and allows the user to provide and record a description in the text.

Graph drawing and description scoring. The application displays a description of the graph. The user manually draws the graph based on the description and simultaneously selects one of the three levels of description clarity. The chosen level is then recorded.

Graph scoring. The application displays the graphs drawn by (n-1) users. The evaluates the accuracy of these graphs, ranks them, and records the assessments.

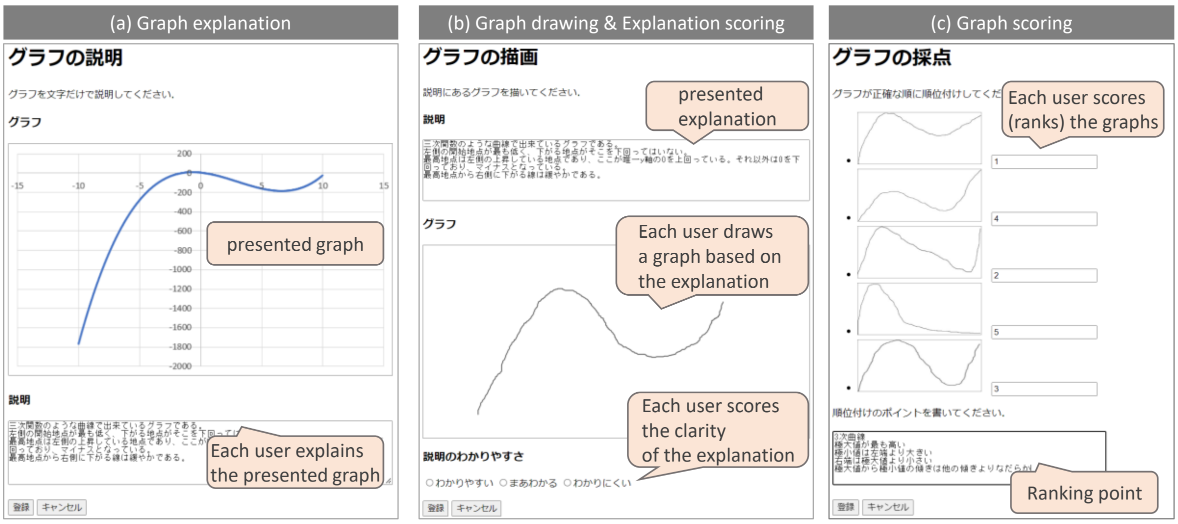

Figure 5. Examples of graph screens including (a) explanation, (b) drawing, and (c) scoring

4.2 Application Implementation

The application was implemented for the web and is compatible with computers, tablets, and smartphones (Android and iOS). Firebase[Moroney 2017], a cloud service provided by Google, was used to handle authentication, database management, and web hosting on the server side. On the client side, HTML, JavaScript, and CSS were employed, similar to standard web applications. The drawing functionality was implemented using Fabric.js, which is a JavaScript HTML5 canvas library. User-owned computers, tablets, and smartphones served as the client terminals.

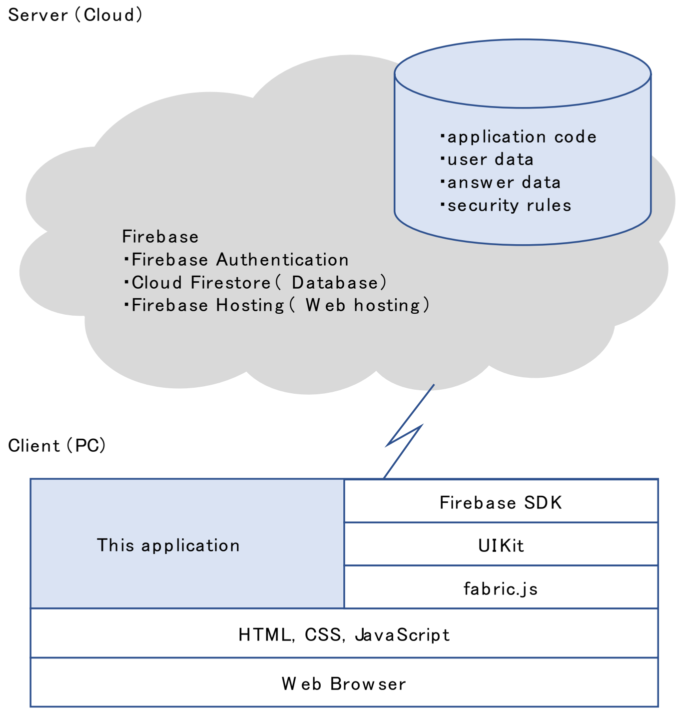

Figure 6. System configuration of the application

5. CONCLUSION

In the context of enhanced IT education, generative AI, and AI/Internet-of-Things applications, the Faculty of Informatics at the Kanagawa Institute of Technology recognizes the importance of strengthening students' ability to think and communicate using their own language, thereby preventing the mechanization of individuals. As part of our efforts to enhance the verbal communication skills of students in the Faculty of Informatics, we developed teaching materials for the verbalisation of mathematical concepts represented as graphs, examined their educational impact, and presented future directions for their development. Through these materials, we gained insights into measuring students' mathematical, comprehension, and explanatory abilities. Verbalising mathematical graphs can pose a challenge for students, as they cannot simply rely on web resources to obtain the correct answer and must engage in reasoning. The results of this study can contribute to improving grade point averages and admission processes. In addition, we plan to explore the relationship between the obtained results and evaluations, such as grades and placement tests during the admission process, to objectively evaluate students' abilities. Moreover, we have plans to develop applications that can serve as teaching materials. We also aim to create resources in the form of audiobooks that can automatically describe graphs to cater to visually impaired students.

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