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Gender Differences in Student Motivation toward NodeBook™ in University Mathematics

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***Abstract*— This study aims to evaluate the effect of gender on student motivation in using NodeBook™, which presents course topics through a visually structured hierarchy that branches and interconnects concepts with flexibility. Traditionally, textbooks and slide presentations are used in STEM subjects. These present concepts linearly, which may limit student learning. This research analyzes data collected from 86 male and 73 female students on structural organization, learning motivation, and overall enjoyment. The results suggest that NodeBook's clear organization successfully meets the needs of female students, who rated course organization and their perception of success higher, consistent with prior findings that female students value explicit structure, while enjoyment and motivation were equally high for all students.**

Keywords*— Cognitive load; educational technology; gender cohorts; mathematics education; NodeBook; student motivation.

I. INTRODUCTION

The effectiveness of learning in higher education in general, and especially in technical education such as engineering, faces challenges related to content, pedagogy, environment, and student-related factors. The adage 'one size does not fit all' is particularly true of pedagogical methods in this area. Traditional technical pedagogy relies on textbooks and slide presentations, which support unidirectional, sequential learning, even though the topics are interconnected. This can reduce engagement and generate anxiety. Many studies indicate that mathematics learning is hindered by such anxiety [1]. As technology has advanced and education specialists have emphasized the importance of learning outside the classroom, technology-enabled platforms that reflect the connections between concepts have gained prominence. These platforms aim to reduce the cognitive load and anxiety of students.

These technology platforms continually strive to improve the quality of their course materials and find new ways to engage students. However, these tools rarely achieve steady acceptance among users. Education literature continues to explore the predictors of acceptance and has identified navigation preferences, clarity and simplicity of the user interface, and the psychological characteristics of students as key determinants. It is interesting to note that most of these factors are influenced by gender. On digital educational platforms, female students focus on the structural organization of content, contextual factors, and predictable relational pathways that reduce cognitive load. In contrast, male students are more likely to choose systems that allow open-ended, trial-and-error-based navigation. These gender differences remain relatively underexplored in the education literature.

This paper attempts to address these gender differences in using NodeBook, an innovative presentation software that helps build knowledge trees by connecting concepts that were traditionally identified as being connected linearly[1]. While it can be used as a concept map, note organizer, or e-book reader, this paper focuses specifically on its application in creating and presenting online courses. A tree data structure is defined recursively as a collection of interconnected nodes, starting from a single root node. Each node is an object consisting of data (in any form) and a list of references to its 'child' nodes [2]. Using courses created with NodeBook technology, students can utilize the new layout and navigation system to promote their success in mathematics, ultimately enabling them to complete their courses and graduate from the colleges they have chosen.

Specifically, this study analyzes the effect of gender on student motivation to learn mathematics-related courses, especially their responses to structural organization, learning motivation, and overall enjoyment. The remainder of this paper is structured as follows: Section II reviews related work; Section III describes the methodology; Section IV presents the data analysis and results; Section V discusses the pedagogical implications; and Section VI concludes the paper.

II. LITERATURE REVIEW

It is now well established that technology helps students worldwide to collate and process course content more quickly and effectively. A growing body of research provides evidence of the impact of technology-enabled platforms in complex learning environments. The effectiveness of such tools is affected by learners' prior knowledge, self-efficacy, and degree of control over navigation [3]. Studies indicate that male students evaluate utility and improved performance, while female students prefer clarity of structure and ease of use [4]. Anxiety in learning mathematics differs between

[1] Available at: https://www.nodebook.ae

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genders, with higher levels in female students, and it is associated with lower performance [5]. To add to this robust body of research, in this paper we attempt to explore gender effects on the perceived benefits of using NodeBook, a software-based instructional platform designed to create visual pathways to connect concepts in mathematics and build a knowledge tree.

Drawing on previous literature, we identified three important constructs that influence student motivation in technical subjects. They are:

i. Students' Perception of Success (SPS)

ii. Students' Enjoyment (SE)

iii. Significance and Need of the tool (SN).

A student's internal perception of success drives self-efficacy and sustains their persistence through challenging foundation-level courses [6]. Students' enjoyment helps to reduce cognitive barriers and mitigates mathematics anxiety among engineering students [7]. Finally, significance and need reflects the practical utility of an instructional tool in bridging the gap between abstract mathematical concepts and real-life applications, such as in engineering [8]. Building on this literature, our earlier study confirmed that these variables are significant predictors of student motivation [9]. We expect that understanding the behavior of these variables in the context of gender will provide vital insights for instructional delivery.

III. METHODOLOGY

We identified all the students of foundation level mathematics of the College of Engineering, Abu Dhabi University as our population. In total 159 students participated in the study. It included 86 male (54.1%) and 73 female (45.9%) students. The proportion indicates a demographic balance, slightly in favor of the male students.

The study intended to apply a quantitative research design to compare the gender-based difference in the motivation to use NodeBook. NodeBook is a software designed for nonlinear text editing and presentation which aims to optimize student engagement in education.

We employed a 12-item questionnaire developed from the Intrinsic Motivation Inventory (IMI) and the Motivated Strategies for Learning Questionnaire (MSLQ). Responses were recorded using a standard 5-point Likert scale. The structural validity, psychometric reliability, and primary predictive capability of this instrument were rigorously established in an earlier study [9]. We ensured adherence to the institutional guidelines and protocol regarding anonymity of subjects and confidentiality. The students participated voluntarily in the survey.

The independent variables in the study included Students' Enjoyment (SE, 3 items), Students' Perception of Success (SPS, 3 items), Significance and Need of NodeBook (SN, 2 items), Mathematics Course Organization (MCO, 2 items). These variables directly predict the dependent variable, namely Student Motivation to Learn Mathematics through NodeBook (SMLM-N, 2 items).

Factor analysis and internal consistency checks from our baseline study confirmed reliability ($\alpha > 0.60$, Kaiser-Meyer-Olkin measure > 0.50, $p < 0.001$). We also employed ordinary least squares (OLS) method to confirm SE ($\beta = 0.397$), SPS ($\beta = 0.366$), and SN ($\beta = 0.209$) to be the statistically significant drivers of overall mathematics motivation, explaining a substantial portion of model variance ($R^2 = 0.640$, $p < 0.001$) [9].

The earlier research was limited in its application to decipher the effect of demographic factors in motivation. To address this limitation, this paper introduces a specialized comparative statistical framework to identify and explore variations between male and female students.

Since the data generated by a Likert scale instrument is ordinal in nature and usually not normally distributed—and in our case it also exhibited strong ceiling effects—the traditional parametric methods such as the independent samples t-test cannot be applied. Accordingly, we applied non-parametric descriptive and inferential analyses. The data analysis was executed using SPSS 26.0. Visual data distributions, dispersion, skewness, and central tendencies were evaluated through comparative box-and-whisker plots. This visual modeling was paired with the Mann-Whitney U test (Wilcoxon rank-sum) to evaluate whether the observed differences between the male and female distributions and median scores across the independent and dependent variables are statistically significant or not.

IV. RESULTS

A comparative analysis for the responses provided by students based on gender is summarized in this section. Five box-and-whisker plots are created to graphically compare the responses of students in terms of their perceptions regarding mathematics course organization, success in the course, enjoyment of learning, the significance and need of NodeBook, and their overall motivation to learn mathematics through this tool. The findings are presented in Figs. 1-5.

Figure 1 presents two box-and-whisker plots that compare the responses of male and female students in terms of mathematics courses organization through NodeBook. The y-axis presents students' responses regarding mathematics courses organization through NodeBook, and the x-axis displays the gender of students.

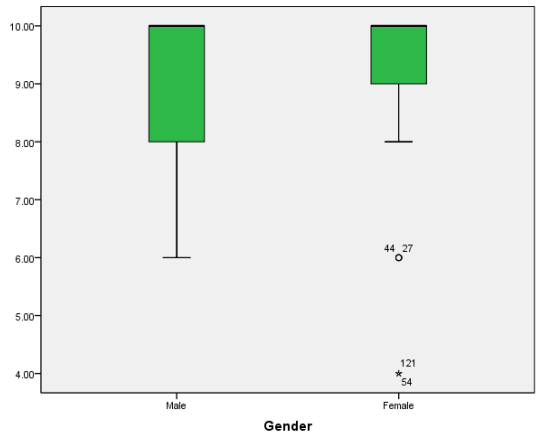

Fig. 1. Mathematics Courses Organization through NodeBook

As shown in Figure 1, the box-and-whisker plot of male students shows wider range displaying higher variability in their perceptions about NodeBook as a tool for organizing mathematics courses compared with female students. The perceptions of female students about NodeBook as an organizer of mathematics courses are higher than male

students. A Mann-Whitney U test confirmed that this difference in perceived course organization between genders is statistically significant (U = 2597.5, Z = -2.152, p = 0.031). However, there are two mild outliers and two extreme outliers marked on the female box-and-whisker plot.

Figure 2 illustrates a comparative analysis of male and female students' perceptions regarding their success in mathematics through NodeBook. The plot for male students shows a much wider box and lower tail, displaying higher variability and lower overall confidence in their success compared with female students, which has some similarity when compared to the pattern observed in Figure 1. Female students demonstrated a higher median and a tighter range of positive scores at the top, which reflects their higher perception of success when using the platform. This difference in the perception of success between genders is found to be statistically significant as indicated by a Mann-Whitney U test (U = 2388.5, Z = -2.711, p = 0.007). It is also noted that female students' plot contains some low score outliers.

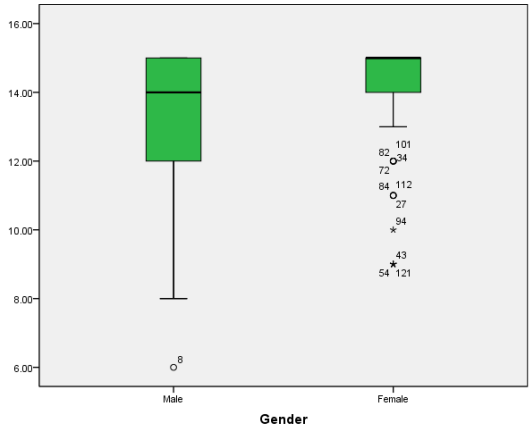

Fig. 2. Students' Perception of Success in Mathematics through NodeBook

Figure 3 compares the responses of male and female students regarding their enjoyment when learning mathematics through NodeBook. In contrast to the previous figures, the plot for male students displays a tighter, higher box plot than the female students, indicating less variability and highly concentrated high scores for enjoyment. Female students, however, have a larger box (wider interquartile range), showing that their enjoyment levels are more spread out and variable compared to the males.

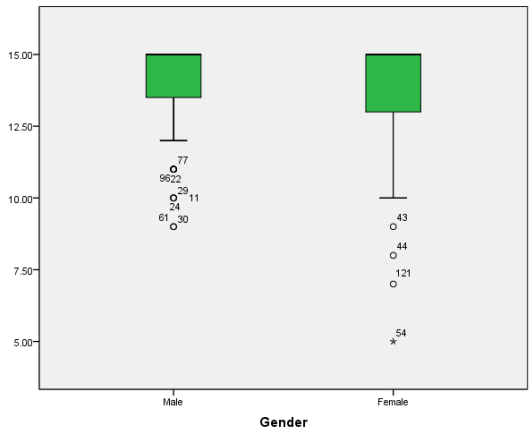

Fig. 3. Students' Enjoyment of Learning Mathematics through NodeBook

Despite these slight visual variations in distribution, a Mann-Whitney U test confirmed that the difference in enjoyment levels between genders is not statistically significant (U = 3019.0, Z = -0.300, p = 0.764). Both groups continue to display a distinct trail of lower-scoring outliers.

In Figure 4, the comparison between male and female students regarding the way they see the significance and need of NodeBook is demonstrated. In contrast to the variations observed in previous figures, the box plots here are almost the same. They both have high scores which indicates a shared, high esteem for the platform's importance when learning mathematics. The difference in perceived significance and need of NodeBook between the two cohorts is found to be insignificant statistically as indicated by a Mann-Whitney U test (U = 3018.5, Z = -0.325, p = 0.745).

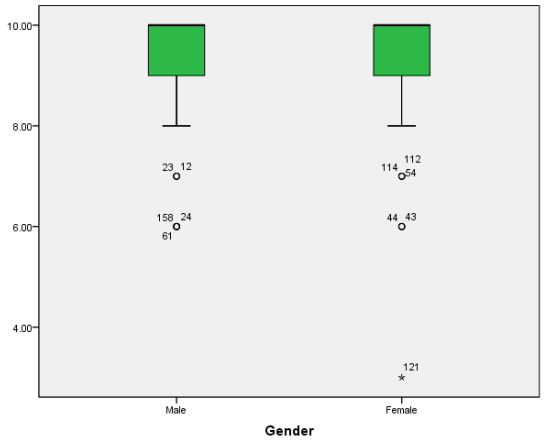

Fig. 4. Significance and Need of NodeBook in Learning Mathematics

Lastly, Figure 5 presents the comparison of male and female students' responses regarding the only dependent variable; students' motivation to learn mathematics using NodeBook. While both genders share identical overall spreads, their median scores differ. The median score for female students is at the top value of 10, while the median for male students is a bit lower at 9. When performing a Mann-Whitney U test, it was found that this small difference in medians is not statistically significant (U = 2934.0, Z = -0.768, p = 0.443), which implies that NodeBook in general engages male and female students equitably.

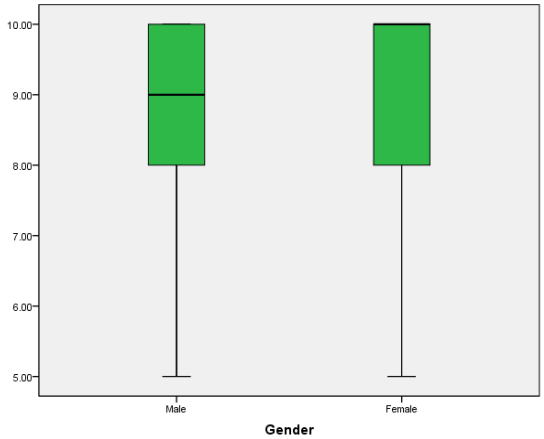

Fig. 5. Students' Motivation to Learn Mathematics through NodeBook

Effect sizes ($r = |Z|/\sqrt{N}$) were small for course organization ($r = 0.17$) and perception of success ($r = 0.21$), and negligible

for the remaining variables. Since five comparisons were performed, the course-organization difference would not remain significant after Holm correction and should be interpreted with caution, whereas the perception-of-success difference remains significant.

The above comparisons show consistently positive ratings of utilizing NodeBook in mathematics instruction across both demographics. Rather than showing a global disparity in engagement, the data reveals that male and female students maintain an equally high baseline of motivation and enjoyment. The true variance is structural rather than emotional; female students rated NodeBook's specific course organization higher and exhibit a higher internal perception of academic success.

V. Discussion

Box and whisker plots indicate that female students' perception regarding courses organization is higher ($p = 0.031$) with low variation when compared with male students. Also, female students' self-evaluation of success is significantly higher ($p = 0.007$) when compared with male students. This indicates a strong connection between the clarity of user interface and learning preferences in female students. NodeBook's nonlinear knowledge tree fosters the required clarity that supports their confidence and sense of control. These results align well with technology acceptance models, which indicate that user-interface clarity and ease of use play a significant role for female cohorts in comparison to male cohorts when adopting a new technology [4]. Conversely, the lower median scores and wider spread in the box plots of male students indicate that they are often less influenced by a system's organizational structure and are more focused on its ultimate utility.

In contrast to the structural and perception of success factors, there were no statistically significant differences between the two cohorts regarding Enjoyment, Significance and Need, and Motivation ($p > 0.05$). The lack of variance when combined with high median scores across both groups, is encouraging for NodeBook as an educational technology as it suggests the pedagogical equity this tool may provide. While mathematics anxiety has been shown to be higher for female students [5], the uniform results of this study across genders indicate that NodeBook provides an equally welcoming interface for all students.

In conclusion, these findings indicate that the visual organization and navigation of various topics offered by this tool is associated with intrinsic value and engagement for mathematics courses universally, crossing gender boundaries without favoring either group.

VI. Conclusion

The gender differences in students' responses to restructuring mathematics concepts using NodeBook are examined in this paper. The results indicate that the visual organization of topics and subtopics was associated with high levels of motivation and enjoyment for both genders. Meanwhile, female students rated the clarity and organization of the courses higher. The findings of this research suggest that NodeBook is perceived equally positively by both genders. In the future, we will focus on using NodeBook in non-mathematical courses and evaluating its impact on student retention and assessment results.

Acknowledgment

H. M. Deif is the founder of NodeBook™ and the inventor of its underlying patented technology [2]. NodeBook is currently offered free of charge and generates no revenue. The other authors declare no competing interests. Student participation was voluntary and anonymous.

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