CHAPTER V
CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The last chapter of this dissertation explains the conclusions, implications and recommendations obtained in this study. Researchers draw conclusions derived from the analysis of data presented from both the collection and processing stages. Furthermore, recommendations are provided to guide further research endeavors within the same thematic domain.

5.1 Conclusion

The researchers have drawn several conclusions based on the processing and presentation of research data, as well as the discussion of the theory of footing as follows:

There is a collective negative effect of students' failure in the five selected mathematics domain on students' performance in electrical and electronic engineering education. Thus, failing to understand the concepts of Algebra, Functions, Trigonometry and Complex Numbers, Calculus and Differential Equations, and Probability will have a negative influence on one's achievement in electrical and electronic engineering. The effect of mathematics failure on students' achievement in electrical and electronic engineering education is mediated by their cognitive failure. Specifically, there is a partial mediation in the relationship between mathematics failure and achievement in the electrical and electronic engineering education by cognitive failure. That is, Students with weak cognitive abilities would do worse below their colleagues with better cognitive abilities. To thrive in developing the cognitive ability for learning in electrical and electronic engineering education, there should be a high level of understanding of the concepts of Algebra, Functions, Trigonometry and Complex Numbers, Calculus and Differential Equations, and Probability, more especially in Algebra and Probability. The research also revealed that students' early foundation in mathematics at the pre-tertiary stages have a moderating role on the failure effects of mathematics on their achievements in electrical and electronic engineering education. This means that,

strong foundation in mathematics is essential for successful completion of the HND electrical and electronic engineering program.

The effects of students' mathematics failure on their achievements in electrical and electronic engineering education can be predicted by the Bayesian multiple regression model. The failure effects on the third semester engineering courses can be better predicted than the fourth semester courses. The third semester courses are therefore seen as more *mathematics reliant* than the fourth semester courses. A classification model, according to its predictive performance classifies the electrical and electronic engineering courses into five: (i) good prediction (ii) average prediction, (iii) poorly prediction, (iv) failed prediction, and (v) worse than random prediction. And this prediction is higher in the earlier semester than the later.

There are ripple effects of mathematics failure on the electrical and electronic courses in the HND curriculum. This means that, students who do not grasp the concepts of either the entire mathematics structure or certain aspects of the engineering mathematics are likely to have its negative effects serially on some courses in subsequent semesters. With respect to the two semesters investigated, the following paths have been found:

Group A (Ripple effects of collective aspects of mathematics):

i. Pre-tertiary mathematics → Engineering mathematics → EEE241 → EEE212

ii Pre-tertiary mathematics → Engineering mathematics → EEE241 → EEE222

iii.Pre-tertiary mathematics → Engineering mathematics → EEE241 → EEE225

iv.Pre-tertiary mathematics → Engineering mathematics → EEE241 → EEE232

v. Pre-tertiary mathematics → Engineering mathematics → EEE241 → EEE242

Group B (Ripple failure effects of specific aspects of mathematics):

i. Pre-tertiary mathematics → Algebra → EEE207 → EEE212

ii Pre-tertiary mathematics → Functions → EEE211 → EEE222

iii.Pre-tertiary mathematics → Trigonometry and Complex Numbers → MCE211 →EEE225

iv.Pre-tertiary mathematics → Calculus and Differential Equations → EEE231 →EEE232

v. Pre-tertiary mathematics → Probability → EEE241 → EEE242

5.2 Implications

Through our research endeavors, the researchers have conducted various analyses regarding the ripple failure effect of mathematics. These analyses have significant implications for students' conceptual understanding, procedural knowledge, and metacognitive abilities, as well as curriculum developers for the electrical engineering program. These implications are as follows:

Negative effect of mathematics failure on students' achievements in their education is an implication that students who are weak in Mathematics below a certain threshold may not be able to progress to the final year, or successfully graduate with the HND electrical and electronic engineering. The findings suggest that a solid understanding of fundamental mathematical concepts and principles may serve as a crucial determinant in the effectiveness of mathematics education for electrical and electronic engineering students. Therefore, efforts to strengthen mathematics education, particularly in foundational areas, may have a significant positive effect on students' performance and success in electrical and electronic engineering studies. The cognitive ability, especially, focusing on the ability of high order thinking skills at the student level is an urgency that must be fulfilled immediately. Therefore, strategic and concrete steps, and immediate actions are needed in various efforts to improve students' cognitive ability to enhance their understanding of the engineering program. Early identification and intervention regarding mathematics failure are crucial for promoting student success in electrical

and electronic engineering education. By addressing mathematics deficiencies in the earlier semesters, educators can improve student outcomes and facilitate a more positive learning experience for aspiring electrical and electronic engineers.

The findings revealed that electrical and electronic engineering courses are unequally affected by mathematics failure. This implies a need for curriculum assessment to understand the role of mathematics in each semester's courses and to potentially revise course content or prerequisites accordingly. The classification model provides a systematic way to monitor the effectiveness of interventions and curriculum adjustments over time. By regularly evaluating the predictive performance of the model and tracking student outcomes, educators and administrators can identify areas of success as well as areas that require further attention and improvement.

Recognizing the ripple effects of mathematics highlights the importance of a cohesive and scaffolded approach to mathematical instruction and curriculum design, ultimately supporting students' long-term success in mastering mathematical concepts and skills. This approach to learning comes with the advantage of allowing learners to easily build confidence and develop skills.

5.3 Recommendations

Based on the conclusions above, there are several recommendations for various parties. Recommendations are devoted to the development of institutions, as policy makers, then to Ghanaian Technical Universities and other higher education institutions as places for students to study and for future researchers. Recommendations for each party are presented as follows:

1. **For Policy-Making Institutions**

This research was conducted in connection with the emergence of several problems in the skill training of electrical and electronic engineering students. Therefore, in addition to strategic efforts, policies made by related institutions to improve students’ ability in mathematics, are also needed. Students should be trained with good result-yielding problem-solving techniques such as the Problem-Based Learning and Realistic Mathematics Education techniques.

Educators and curriculum designers may need to consider the longitudinal progression of mathematical concepts across courses when designing curriculum pathways. They may need to ensure coherence and alignment between courses to support students' continuous development of mathematical skills.

2. For Ghanaian Technical Universities and Other Higher Education Institutions

Higher education institutions also have a significant role in the development of students' high order thinking skills, therefore the teaching process in the higher education environment should also be directed to the development of high order thinking skills both academically and non-academically.

As revealed by the research, students with weak mathematics background, specifically grade 4 or worse, may be identified and given interventions in the form of remedial studies prior to the start of the tertiary program, and also tutorials and other mathematics supports during the tertiary program, to boost their capability on the electrical and electronic engineering program.

To prevent cognitive failure, students should do continuous revision and problem-solving among these topics of mathematics from textbooks used in mathematics learning in primary, secondary, and tertiary schools, with much attention to Algebra and Probability. Teachers should engage students in appropriate methods of teaching and learning mathematics concepts to promote students' critical and creative thinking.

Instructors and learners must give attention to learning paths consisting of courses that need the concepts of specific aspects of mathematics, and put in more efforts in these areas in other to achieve success. Instructors can implement instructional strategies that emphasize the integration of foundational mathematical concepts across different courses. This could involve providing opportunities for students to revisit and reinforce previously learned mathematical skills in subsequent courses.

Instructors handling the third semester electrical and electronic engineering courses may need to be aware of the increased mathematics reliance and may need to adapt their instructional strategies or provide additional support to help students succeed. This could involve incorporating more mathematics instruction or

providing resources for students who need extra assistance with mathematical concepts. Both instructors and students must notice that EEE241 (Power Systems I) is very critical on the path, and must be given attention with respect to applications of mathematics.

The findings of the research underscore the importance of ongoing professional development for educators to enhance their understanding of the interconnectedness of mathematical concepts and develop strategies for effectively supporting students' mathematical progression across courses. The institutions involved may run courses and career workshops for professionals who are out of active mathematics classrooms, with courses that do not need strong mathematics concepts to understand.

3. For future researchers

The study of the failure effects of mathematics still needs further and more in-depth development. The research conducted by the researchers considered only five important mathematics indicators for the study, and these indicators, together with students' mathematics background results, explained only 51.6% of the variation in students' achievements in electrical and electronic engineering education. We therefore recommend that more areas of engineering mathematics and other factors such as the category of high school attended by the students, sex of the student, mode of admission (direct or mature entry) and students' attitude towards program of study, which may explain the unexplained variation in the students' achievement, may be investigated by future researches.

The researchers considered only two semesters for the investigations into the ripple effects of mathematics on the electrical and electronic engineering courses in the Ghanaian technical universities. We therefore recommend that future researchers may consider more semesters in addition, and where the courses are electives (taken by subgroups of students), branches of the ripple effects may be studied.