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Transforming Learning and Assessment Through the Application of Big Data and Artificial Intelligence
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Assessment in a data-driven world: rethinking student success

Foundational Mathematics Course Case Study

Authors and presenters:

Tatiana Sango, University of Cape Town (UCT), tatiana.sango@uct.ac.za

Kate Koch, Rhodes University (RU), k.koch@ru.ac.za

Introduction

- Student-success narratives (South African perspectives)
- First-year courses and students
- Assessment instruments in this study
- Adaptive learning in response to assessment
- Relevance of the study
- Focus of the study:

  (1) Develop a curriculum that integrates data analytics (NBT and course-level assessments) and ALEKS adaptive learning to design support for first-year students with gaps in mathematics knowledge.

  (2) Investigate the potential of adaptive learning systems to facilitate a smoother transition from school mathematics to first-year university mathematics for incoming students.

  (3) Understand how adaptive learning could be effectively implemented to accommodate varying levels of academic preparedness among first-year students.

Student success narratives

- Each university defines success based on its unique history and context.
- University of Pretoria (UP): View student success as a holistic process that goes beyond academic achievement, emphasising the development of employable skills, social responsibility, and personal growth. https://www.up.ac.za/article/2749212/student-success

  UP emphasises high-quality teaching and learning and relevant curricula, as well as the quality and integrity of assessments. https://www.up.ac.za/media/shared/391/pdfs/student-success-at-up.zp228623.pdf
- University of Free State (UFS): Understanding students and putting them at the centre of institutional design. https://www.ufs.ac.za/docs/librariesprovider35/default-document-library/understanding-student-putting-students-at-the-centre-of-institutional-design.pdf?sfvrsn=2b398d21_0
- Stellenbosch University (SU): Emphasis on leadership preparation alongside academic standards, aiming to cultivate students who can contribute positively to society. This approach recognises that high graduation rates alone do not equate to successful outcomes if graduates lack critical thinking and social awareness. https://usaf.ac.za/successful-students-do-more-than-graduate-they-are-equipped-to-be-responsible-citizens/
- Rhodes University (RU): defines student success as a journey that involves personal growth, academic achievement, and the ability to overcome challenges with perseverance. Through initiatives like the Extended Orientation Programme, RU emphasizes the importance of discipline, self-motivation, community engagement, and the development of essential life skills to empower students to thrive both academically and personally throughout their university experience https://www.ru.ac.za/latestnews/gearingupfirst-yearstudentsforsuccess.html

Student success narratives

- WITS University: Aim to create the best possible teaching and learning environment to foster academic excellence. The Wits Institutional Framework for Student Success provides a comprehensive structure to support this goal, integrating research to ensure that student success is continuously strengthened and supported. https://www.wits.ac.za/about-wits/wits-2033/academic-excellence/
- Nelson Mandela University (NMU): Recognising the diversity of students' backgrounds, experiences, goals, and aspirations; offering the necessary support, resources, and environment to empower each student to reach their full potential and achieve their own unique version of success. https://nmu.edu/success/student-success-and-wellness
- University of KwaZulu-Natal (UKZN): Fostering an environment that supports all students in their academic journey. The University is dedicated to promoting personal intellectual growth while equipping students with the skills and knowledge to navigate the challenges and responsibilities of a rapidly evolving, competitive, and diverse world. https://ukzn.ac.za/student-portal/
- UCT DASS: “DASS provides educators and decision-makers at UCT with a comprehensive suite of powerful tools. By utilising our services, you can make informed, data-driven decisions and enhance courses, programmes and systems to promote optimal student success outcomes.” https://dass.uct.ac.za/
- How will success be measured? Assessment policy by three universities: https://www.uwc.ac.za/news-and-announcements/news/three-south-african-universities-have-new-approaches-to-assessing-students-why-this-is-a-good-thing

Student success in South African universities

- Student success in South African universities is defined and viewed through a multifaceted lens, emphasising not only academic achievement but also personal development, social responsibility, and inclusivity.
- The initiatives targeting success in higher education must be intentional, well designed and implemented at scale. (https://usaf.ac.za/what-does-student-success-mean-and-how-can-universities-contribute-to-it/)
- Research indicates that student success should not be limited to grades and academic accomplishments. It encompasses psycho-social dimensions, personal transformation, and the preparation of students for responsible citizenship.
- Institutions are encouraged to integrate academic support with personal development initiatives to foster a holistic educational experience.
- Students themselves cannot be seen as passive recipients of "success", they should be actively recognising and communicating the need, and the institutions of higher learning need to be able to respond with relevant strategies that remove barriers. Successful students are more than just graduates, they are ready to become global citizens. (https://usaf.ac.za/successful-students-do-more-than-graduate-they-are-equipped-to-be-responsible-citizens/)
- What matters to students in HE defines their success: finance, quality of education, *academic success*, earning a degree, *timely graduation*, skill set and employment (https://ddp.org.za/blog/2020/11/11/what-really-matters-for-students-in-higher-education-institutions-in-south-africa/)
- Factors that influence: the articulation gap, pedagogical challenges, language challenges, large classes, privileged knowledge, diversity, large classes https://kresge.org/sites/default/files/Issues%20and%20Interventions%20in%20South%20African%20Universities.pdf

Academic success in first-year courses

- Knowing how to succeed
- Transition challenges
- Support systems and student well-being
- Learning strategies
- Engagement in learning
- Often course-specific
- Reliant on prior knowledge
- Courses that impede graduation (Shay et al., 2019)
- Course success and student success
- The role of assessment in academic success:
  - Alignment with course outcomes
  - Purpose
  - Assessment load and balance
  - Student feedback

Relevant ideas in literature

- This study is based on two key areas of literature:

  (1) assessments of student learning and their impact on first-year mathematics education; and

  (2) the incorporation of digital, assessment-driven student support mechanisms into traditional course delivery.
- Assessments of student learning to facilitate feedback for students: varied assessments; timely information; evidence of learning; and positive impact on motivation.
- Assessment and learning resources: increased student engagement and motivation.
- Importance of self-reflective learning tasks in building competence & confidence.
- The use of learning analytics for course performance measurement and improvement of curriculum delivery.
- Knowledge Space Theory (KST) and Intelligent Tutoring Systems (ITS) as an approach in teaching and learning.

Learning support model

- The intended solution in this study uses the NBT data and relative importance analysis of the NBT subdomains with course-specific assessment data.
- Five foundational modules aligned with these diagnostics were integrated into the first-year Mathematics course in ALEKS.
- First-year students from a South African university used ALEKS to complement their mathematics course programme.

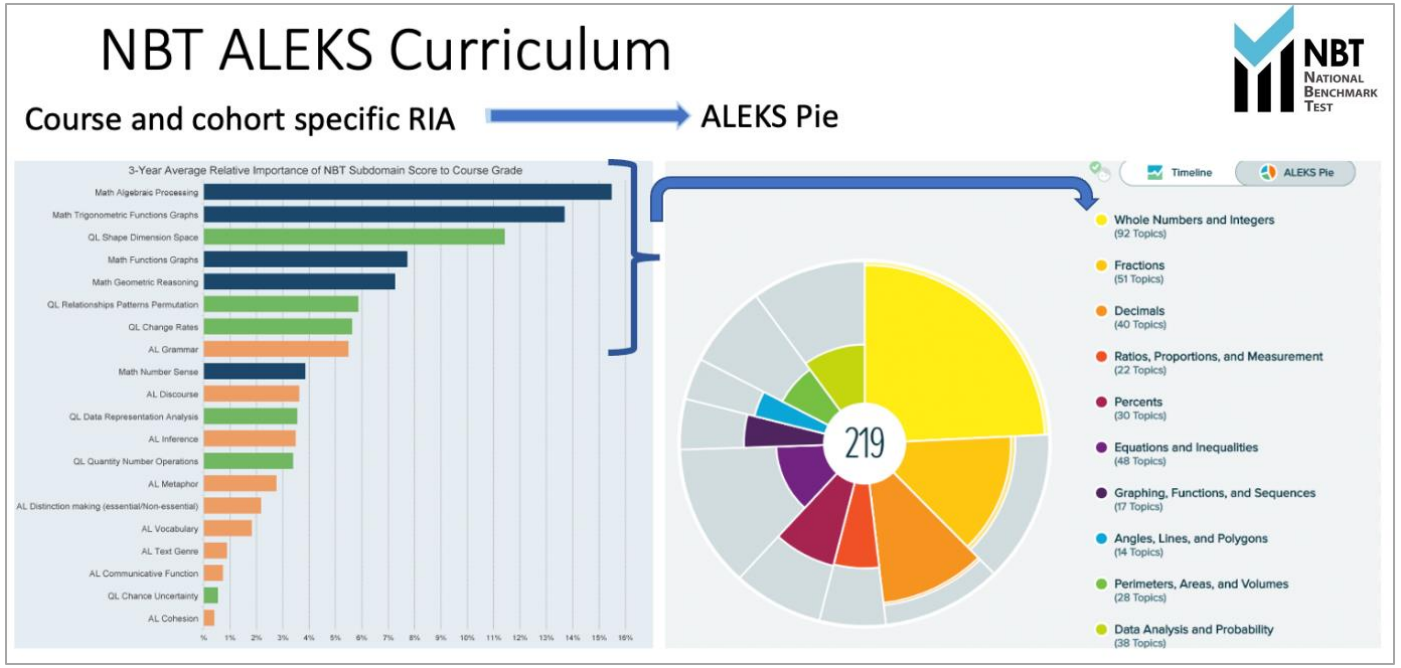


Figure 1: An example of the ALEKS Pie integration with foundational modules

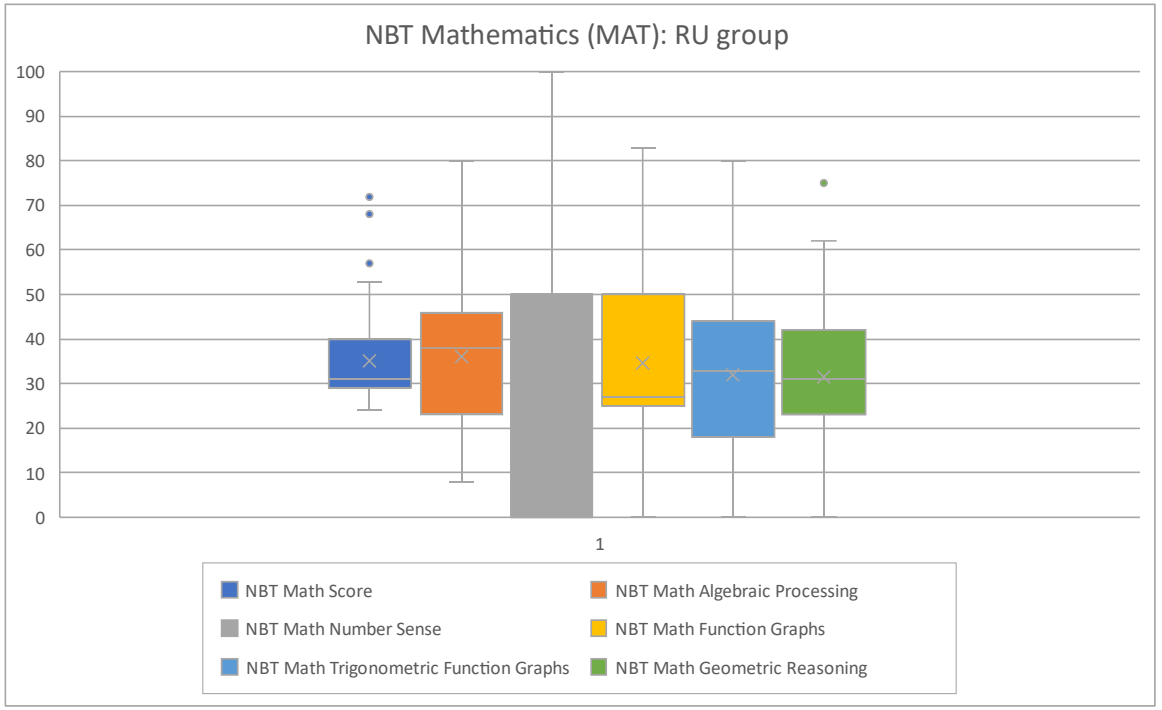
Mc Graw Hill ALEKS®

ALEKS Intro

ALEKS Intro Video

Case study: First-year Mathematics bridging course for Science Students

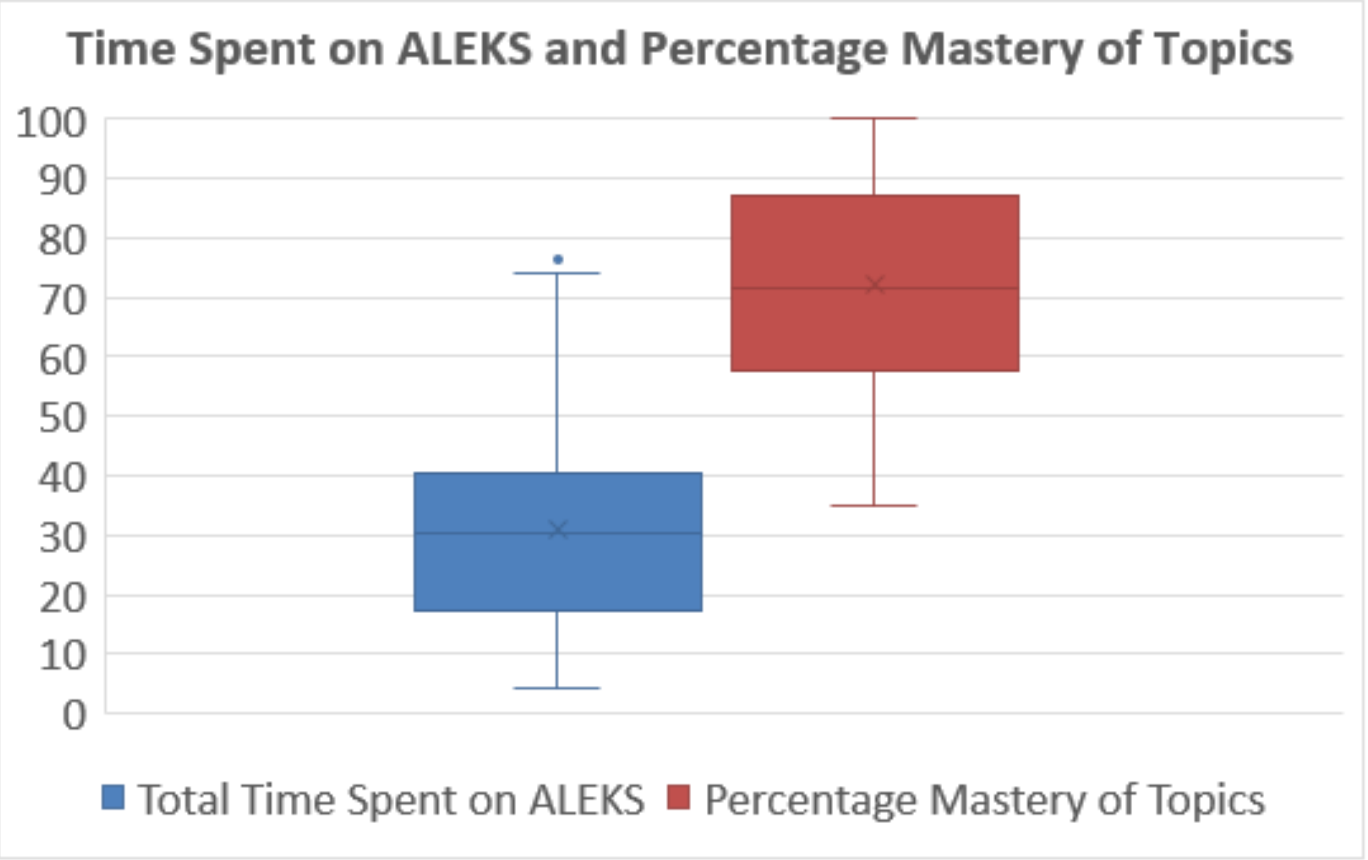
- Science Extended Curriculum students at Rhodes University take MAT1F in their first year (56 students in 2024).
- ALEKS formed part of the course in 2024 with tailor-made Modules based on National Benchmark Test data and the course curriculum.
- The overall National Benchmark Test (Maths) performance for this cohort was low indicating that students would need additional support.



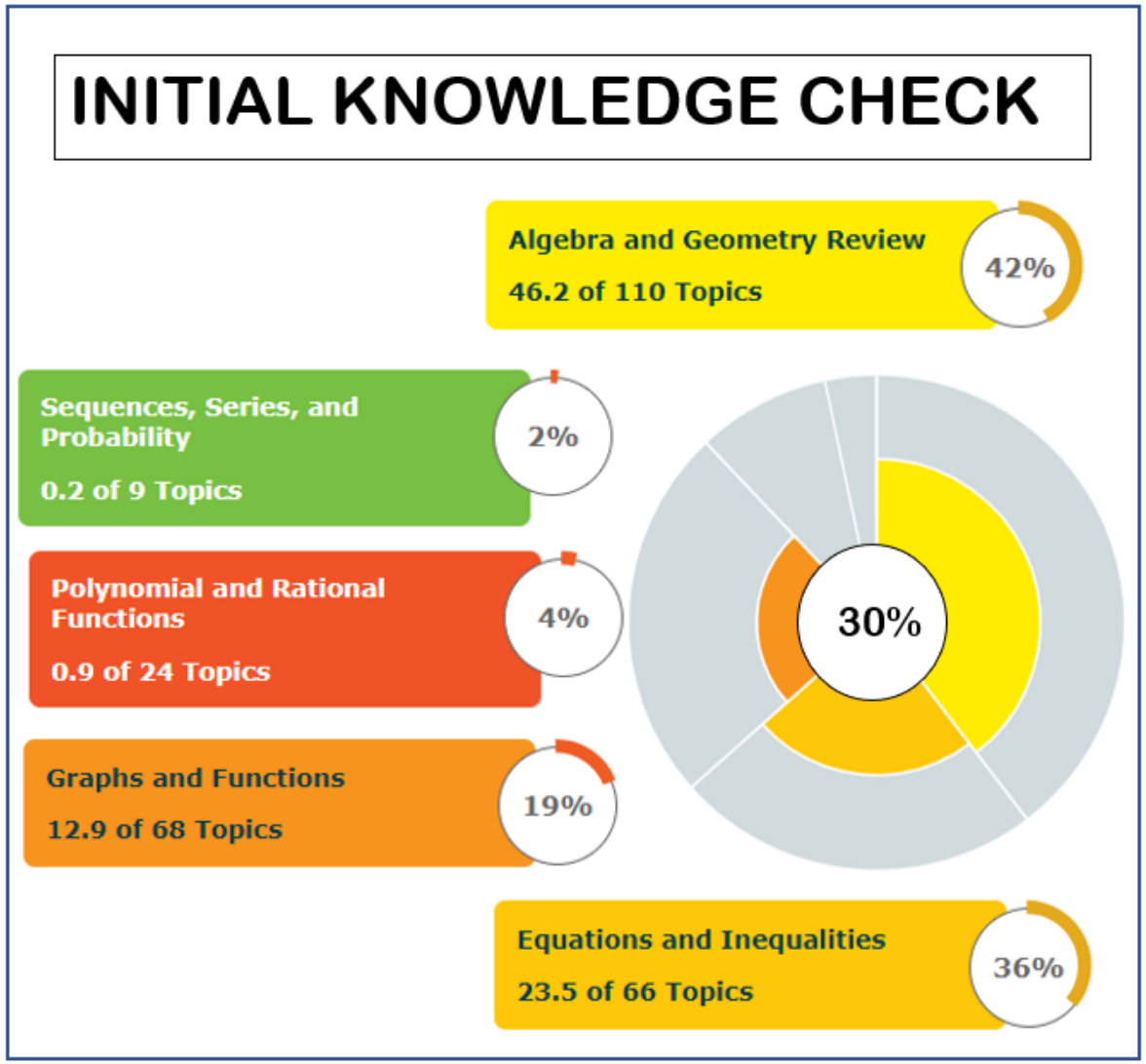
NBT National Benchmark Test

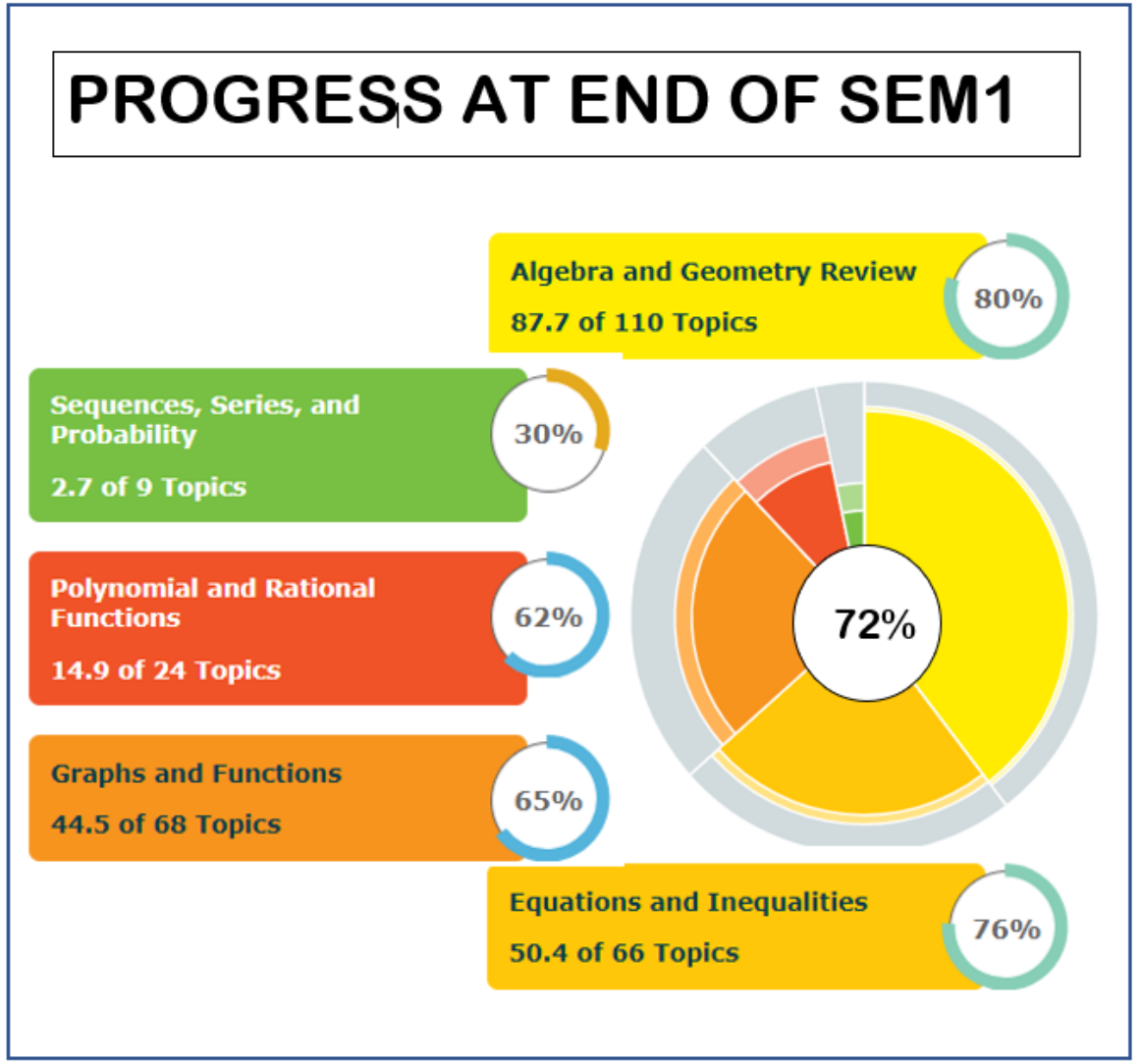
Time Spent on ALEKS and Percentage Mastery

- Students worked an average of 31.1 hours in ALEKS (2.5 hours per week) with a range from 4.2 to 76.4 hours.
- The average number of topics mastered at the end of the semester was 72% (range 35%-100%).
- 6 students achieved 100% mastery of ALEKS Topics.

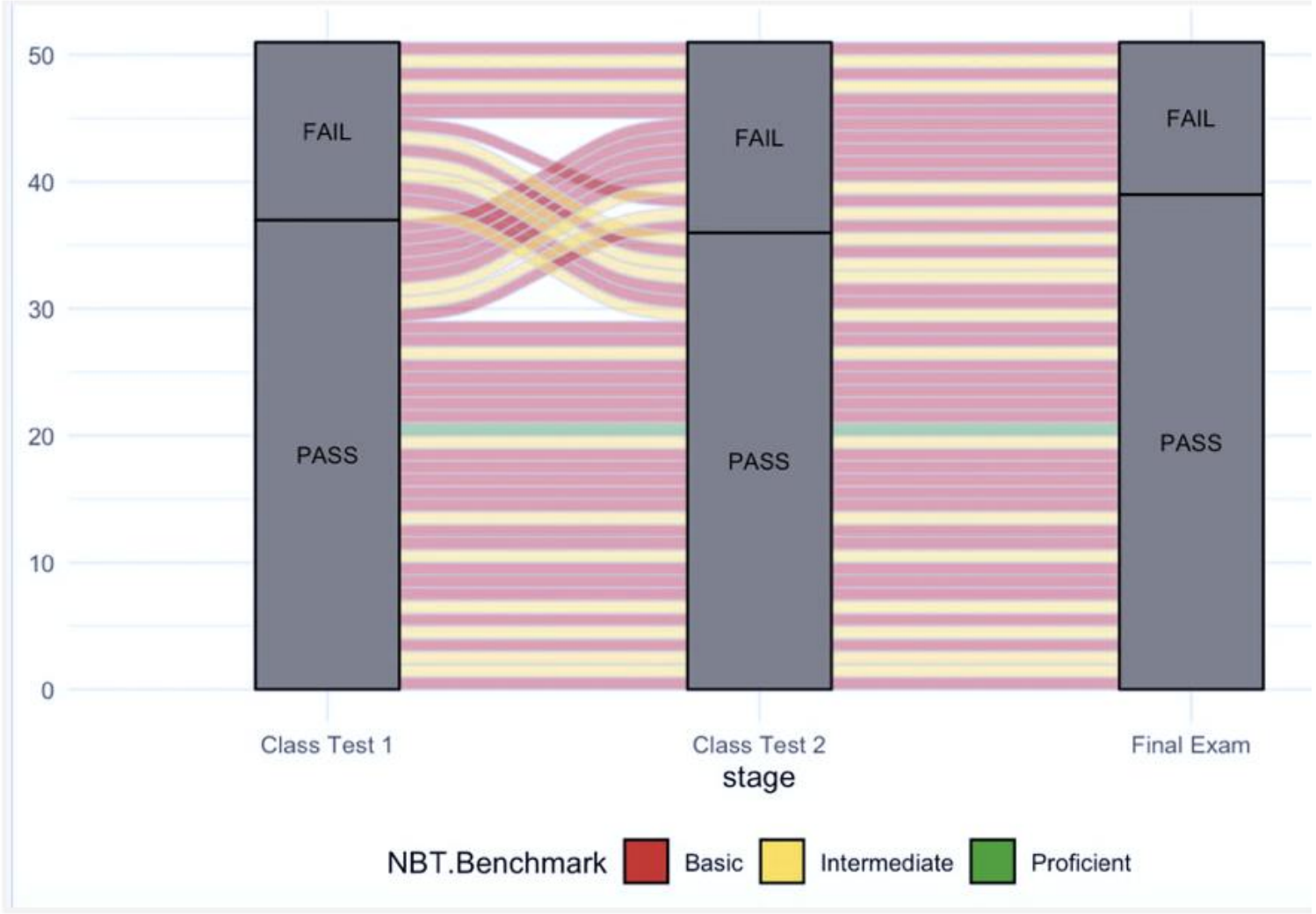


ALEKS Pie Progress



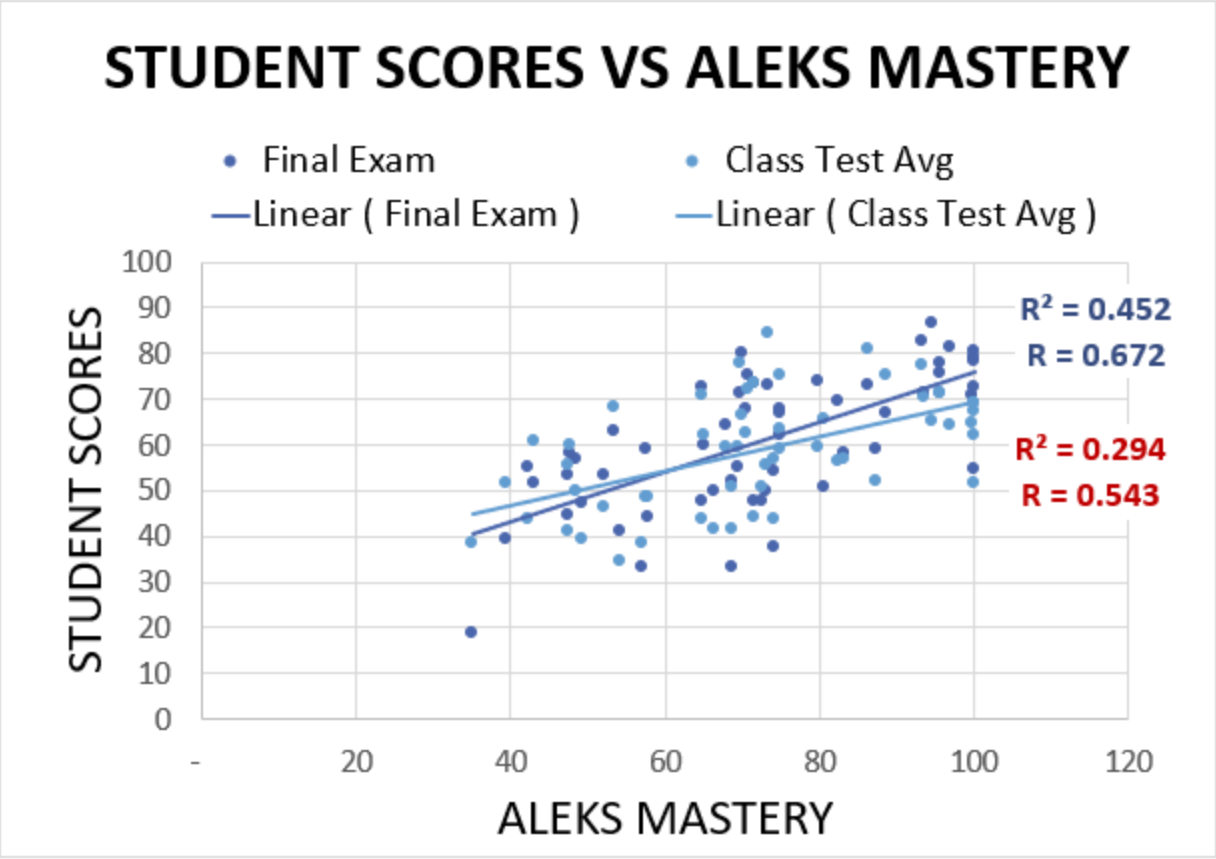


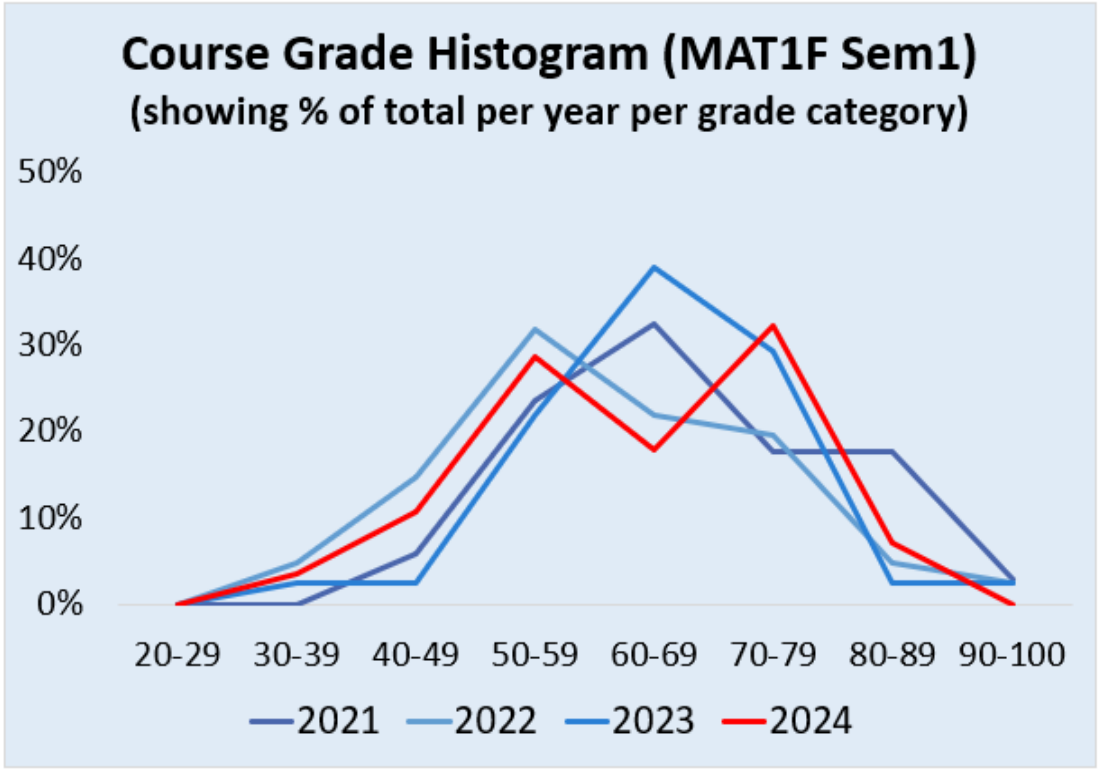
Students' scores in course assessments



	No. of students	Total time in ALEKS			ALEKS mastery (Pie completion)	
		Less than 20h	Between 20h and 40h	More than 40h	Less than 70%	More than 70%
Consistent 'PASS'	29	7	11	11	5	24
Consistent 'FAIL'	6	2	3	1	5	1
Scores changed across assessments	16	9	4	3	11	5
Final Course 'PASS'	43	15	15	13	14	29
Final Course 'FAIL'	8	3	3	2	7	1

Results


STUDENT SCORES VS ALEKS MASTERY
Final Exam
Class Test Avg
Linear (Final Exam)
Linear (Class Test Avg)
STUDENT SCORES
ALEKS MASTERY
R² = 0.452
R = 0.672
R² = 0.294
R = 0.543


Course Grade Histogram (MAT1F Sem1)
(showing % of total per year per grade category)
50%
40%
30%
20%
10%
0%
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-100
2021
2022
2023
2024

Results – June Final Mark vs ALEKS Pie Progress

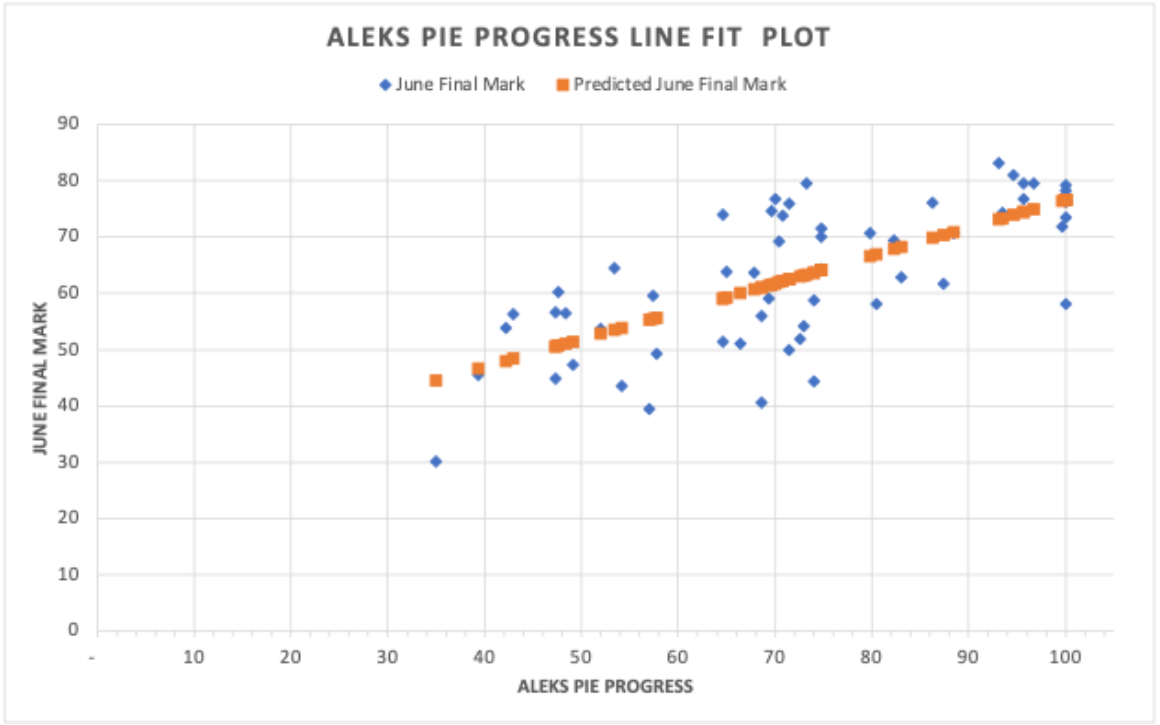
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.69911528
R Square	0.48876218
Adjusted R Square	0.47929481
Standard Error	9.22203881
Observations	56

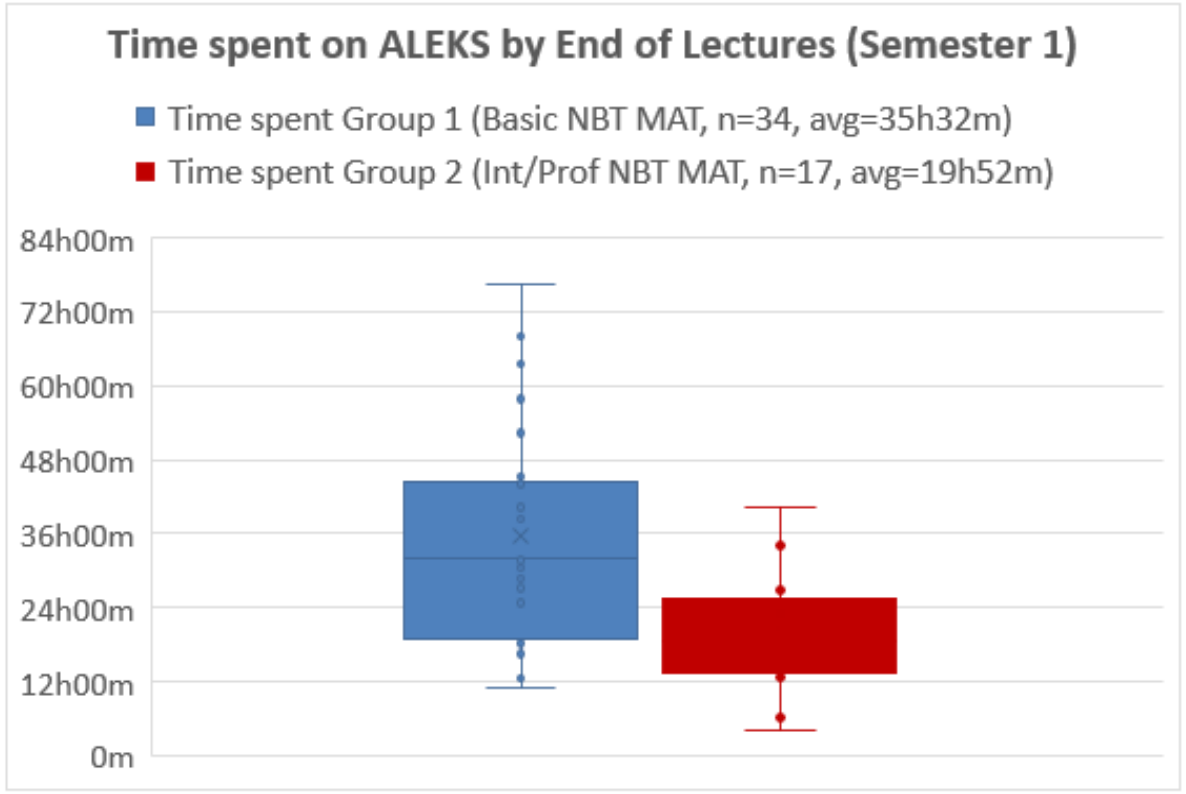
ANOVA

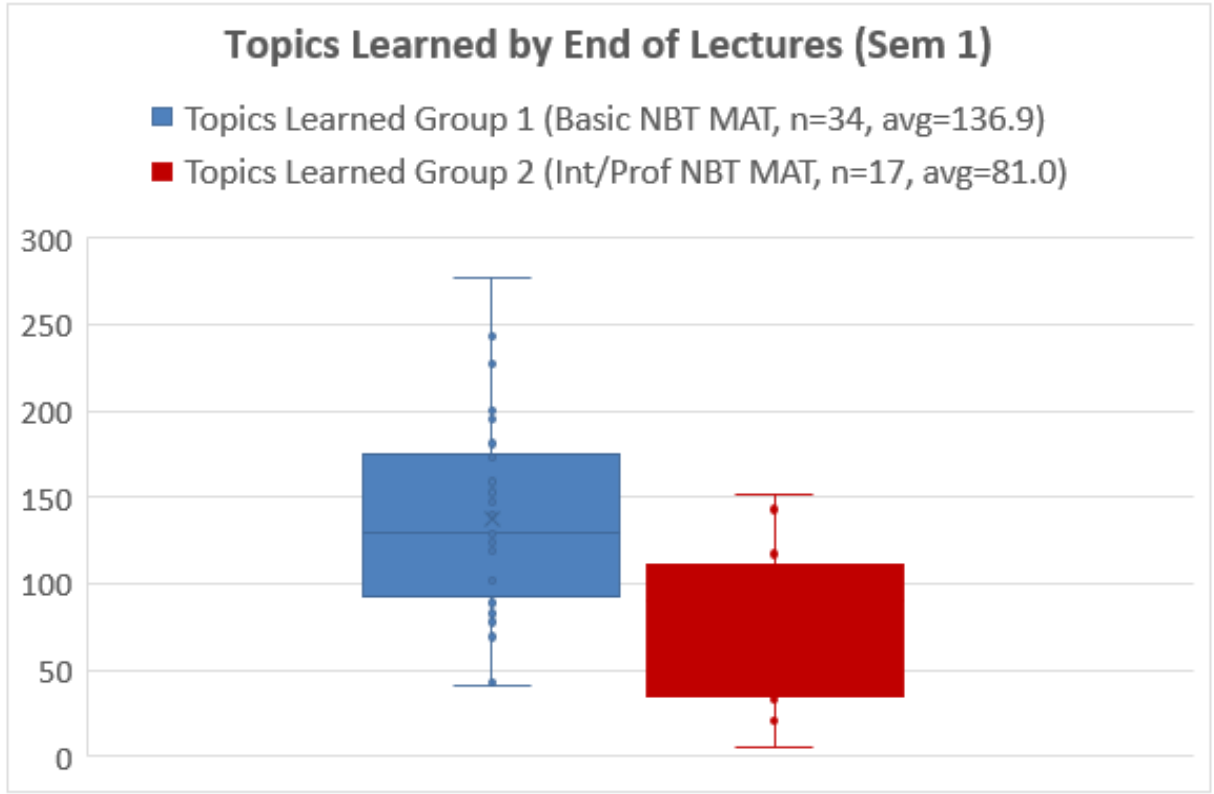
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4390.583801	4390.5838	51.6259884	2.0617E-09
Residual	54	4592.483992	85.0459998		
Total	55	8983.067793			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	27.150274	5.112982974	5.31006541	2.1175E-06	16.8993603	37.4011877
PieProg	0.49451946	0.068825472	7.18512271	2.0617E-09	0.3565327	0.63250623

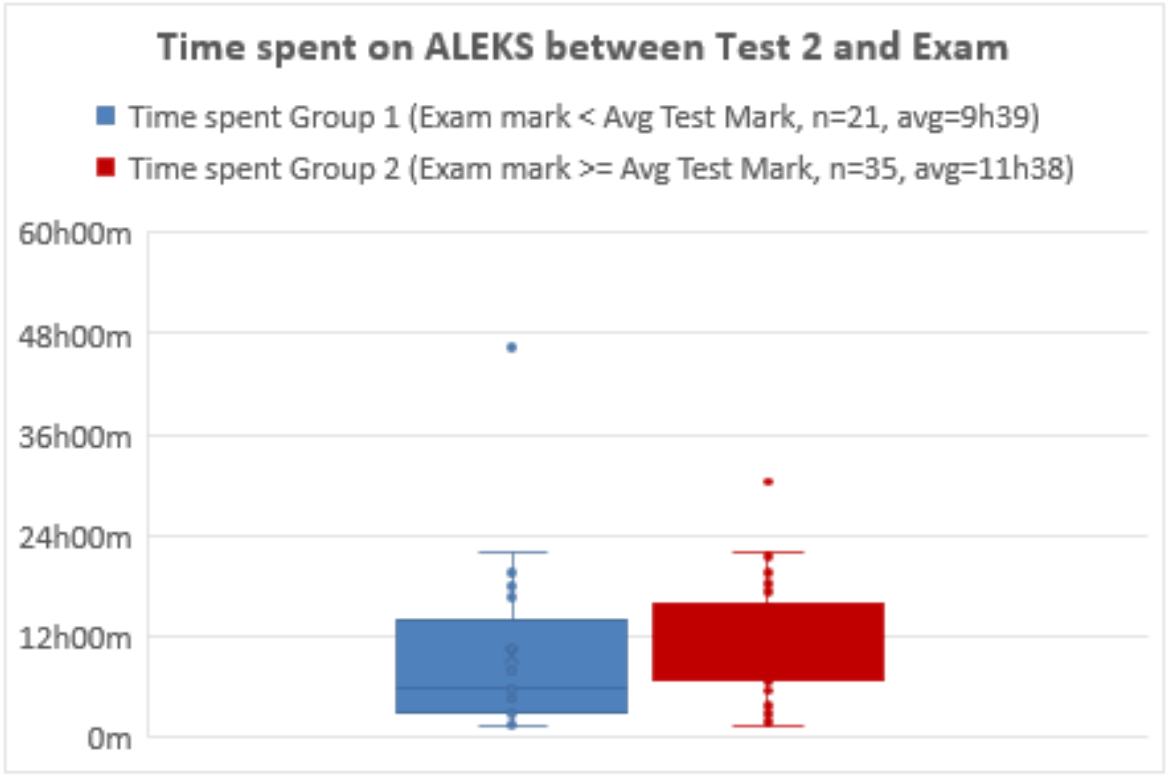


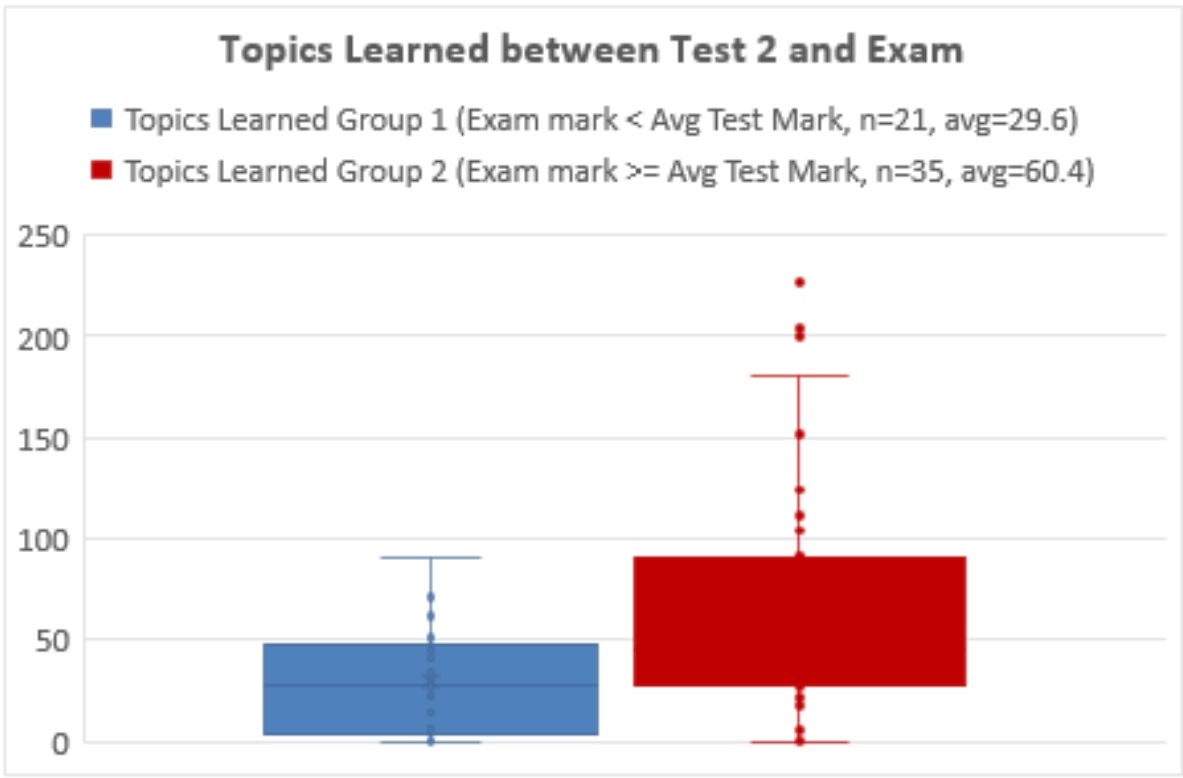
Results by NBT MAT Level



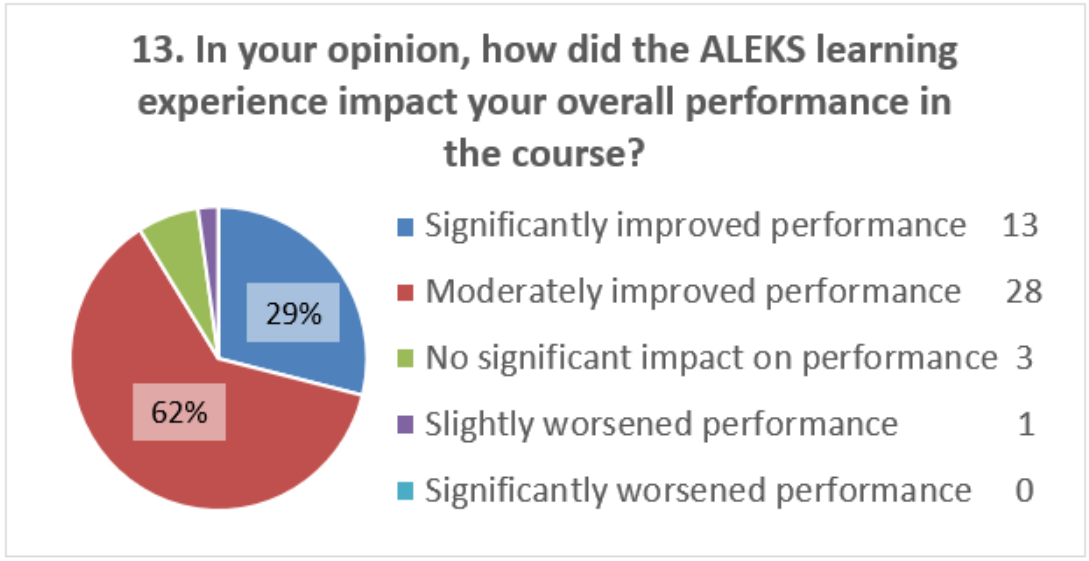


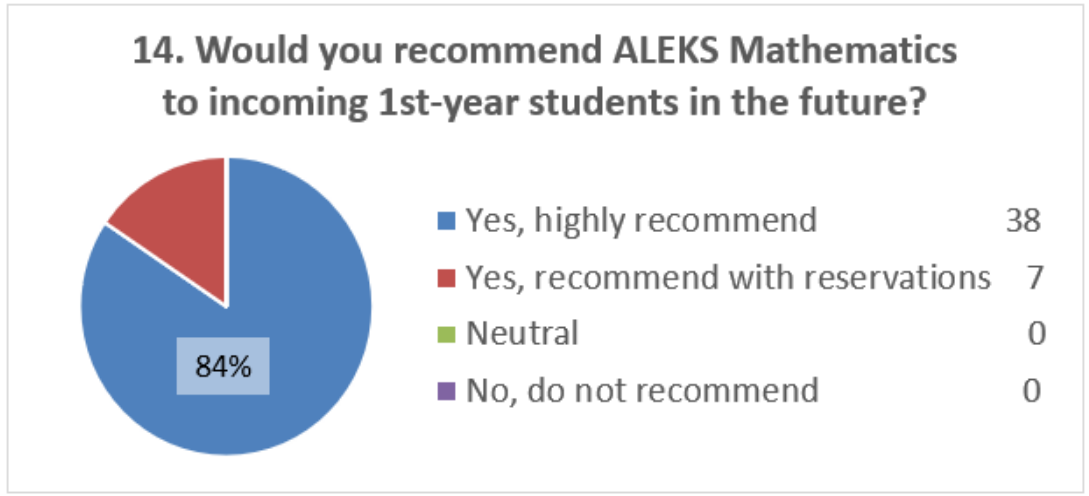
Results - improvement in marks between Test 2 & Exam





Survey results





*"In my experience with ALEKS, I can say that **it's a great tool if you want to know where you need to focus more in Mathematics topics** and when you're doing a mathematical problem and you get stuck you can always ask for an explanation. The explanations are clear and easy and that's what really made me to get better and better."*

*"It was **a fun and exciting experience**. I would highly recommend it to future first years as ALEKS helps improve maths logic."*

*"ALEKS Mathematics has really been a helpful platform with regards to my MAT1F performance. **It has helped me to overcome some of my weaknesses** ... It has been an amazing experience."*

*"ALEKS is very helpful when it comes to Mathematics and learning. Not only does it give you examples but **it also helps you know where you need to put more effort in learning.**"*

Conclusions & further research

- The integration of an adaptive learning digital tool in a Foundational Mathematics course was effective in supporting student learning.
- The close alignment of the ALEKS modules with the Foundational Mathematics Course content and the integration of digital assessments through ALEKS as part of the course encouraged student engagement with the ALEKS platform and supported student learning.
- Student feedback on using ALEKS was overwhelmingly positive and most said it improved their performance in the course, and that they would recommend it for other first year Mathematics students.
- Students falling within the National Benchmark Test (Mathematics) 'Basic' and ‘Intermediate’ benchmarks could benefit greatly from supplemental assistance through ALEKS.
- Further research into improving student learning by including different types of ALEKS assessments and the pacing of ALEKS learning to follow topics as they are covered in the Foundational Mathematics course would be useful.
- The findings of this research indicate that ALEKS could be used effectively to support student learning of Foundational Mathematics in other University courses or interventions.

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Thank you!

Authors and presenters:

- Tatiana Sango, University of Cape Town (UCT), tatiana.sango@uct.ac.za
- Kate Koch, Rhodes University (RU), k.koch@ru.ac.za

ALEKS Team (Africa):

Blake Baudean

blake.baudean@mheducation.com

Manager, ALEKS International

Dubai, UAE | GST