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The transition from school mathematics to university mathematics: Implications for teaching and learning:

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Introduction

- Numerous changes to the South African curriculum since 1994
- Nated 550 report – consolidated and then provincialized; then nationalized in 2001 (DNE - Department of National Education, now DBE)
- NCS – 2006; grade 12 in 2008
- CAPS (NCS Grade R-12) – 2012; grade 12 in 2014

Mathematics changes

- Mathematics: Higher Grade and Standard Grade in grades 10 – 12; and those who did no mathematics, up to 2007
- NCS Mathematics (core) from 2006; First grade 12 in 2008
- Mathematical Literacy introduced in 2006; first grade 12 in 2008
- Consolidation and changes: CAPS in 2011/2012; first grade 12 CAPS in 2014
- Technical Mathematics in 2016; first grade 12 in 2018

Why changes?

- Curriculum is not static
- Adapting to changing circumstances in South Africa as a whole
- Changes in communities and schools
- Changes in higher education
- Changes in the job market; preparation for the 4IR; 5IR

Why study Mathematics at schools?

- Love of subject (intrinsic value)
- Intellectual development
- Everyday use (utilitarian value)
- Other subject study

Choosing a university programme (with mathematics)

- Build on learning at school to a more advanced level
- Pattern and structure in widely different areas of science and technology; mathematics of these patterns can be used to explain and control natural happenings and situations.
- Calculations within these patterns and structures
- Logical analysis and deduction; problem solving
- Mathematics has a significant influence on our everyday lives,and contributes to the wealth of the country.

21^{st} Century skills

1. Problem Solving: The ability to solve complex problems in the real world is a valuable skill; problem-solvers can work independently without supervision as they are unafraid to make and learn from mistakes

2. Analytical Thinking: Students need the ability to think analytically. This includes being proficient in making comparisons, contrasts and evaluations, and then taking actions based on analysis without instruction or supervision.

21^{st} Century skills

3. Collaboration: Students must possess the ability to collaborate seamlessly in both physical and virtual spaces, with real and virtual partners at any location. Connection and collaboration with others are essential not only to students' learning but also to their mental and emotional health. (ICT Projects; SAMTC)

4. Communication: With the existence of as well as an increase in methods of communication, students must be able to communicate in different multimedia formats and not just with text or speech. (Graphs; Pictures; Social media :authentic news)

21st Century skills

5. Ethics, Action, and Accountability: A well-rounded and responsible global digital citizen can contribute towards a better world by practicing personal, global, and online responsibilities. As individuals, we should be respectful of other cultures and belief systems and be diligent about being at our best when in our interactions with others, both online and offline. (anti-corruption; climate change; inclusive approach)

Mathematics features in all five of these 21st century skills

Transitions in education

- Grade R to grade 1
- Grade 3 to grade 4
- Grade 7 to grade 8
- Grade 9 to grade 10
- Grade 12 to first year of tertiary education (university)

The transition from school to university: Improving the first year experience

- Engelbrecht and Harding (2015): initiatives at university level to improve the first year experience of students and ensure a successful transition from the school environment to the tertiary environment
- Procedural approach in teaching and examination coaching at schools tend to exacerbate this transition
- Students have to move towards a more conceptual thinking approach and independent learning at university:
- Refresher courses; adapting the curriculum; focus on "at risk" students; continuous online engagement; student tutors; repeated exposure; summer and winter schools

The transition from school to university: Extended Studies

- Provision of extended studies in various faculties.
- An extended degree programme or bridging course is an intensive course designed for high school learners who may not feel confident about their preparation for university studies or do not meet the requirements for certain programmes.
- An extra year is added to the degree programme, thus making a three-year degree programme into a four year programme (Erasmus, 2020). (adapting the curriculum)

Mathematically related courses

- **Mathematics and/or Applied Mathematics** courses which are taken as a major in an under-graduate degree programme of a Faculty of Science.
- These may be taken up to third year level and would provide access to post-graduate studies involving specializing in a field or branch of mathematics.

Mathematically related courses

- **Specialist Mathematics** courses are mostly linked to programmes in the Faculties of Science or Engineering, but may also form part of advanced programmes in Commerce and Education.
- This may include Engineering Mathematics, Actuarial Mathematics, Mathematical Statistics, Mathematics (for Teaching), and others.
- These courses may go up to second or third year level as part of first degree programmes or may be pre-requisites for other mathematics related graduate and post-graduate studies.

Mathematically related courses

- **Service Mathematics** courses may be taken in most faculties such as Science, Commerce, Health Sciences, Education and Engineering faculties.
- These courses are usually offered at first year level and may comprise one or two modules

MAA Report 2014

- Mathematical Association of America (MAA) (2014): “foundational” and “crosscutting” role of the mathematical sciences in fields such as medicine, engineering, technology, biology, chemistry, social sciences and other fields.
- Members of Mathematics departments – collaborate with colleagues in mathematics-intensive disciplines in order to heighten the relevance of their courses to their students
- Investigate new teaching methodologies and technologies in an effort to retain and motivate students
- Relevance to South Africa*

Relevance of Mathematics in university programmes

- Kishore (2018) states that mathematics is a "way of thinking" and a universal language with an "omnipresence" of numbers.
- The subject an integral part of our very existence: "your way of approaching problems analytically and logically" determines "how good you are in the subject".
- Logical thinking can be applied to problems in Computer Science, Coding, Business, Investing, Statistics, Data Sciences and other fields.
- Research mathematics is not the only way to demonstrate mathematical strength and that conceptual clarity in mathematics with strong fundamentals may help students in any field

Creating a mathematically literate society

- Mignton (2020): A lack of mathematical know- how of approaching political and social issues in a more rational way eg) COVID-19 politicised in the USA; listening to the scientists?
- 2008 Financial crisis occurred because people did not understand the impact of their mortgage rates increasing slightly
- Environmental crisis: People are afraid of mathematics or numbers and are unable to see the consequences of their actions.
- Mathematics teaches you "to create arguments, look for hidden presuppositions, to see patterns and create inferences".
- Probability - learn to consider all possibilities rather than just accepting the first explanation of an event.
- Being confident in one's problem-abilities would enable one to think deeply about the problems before arriving at an opinion

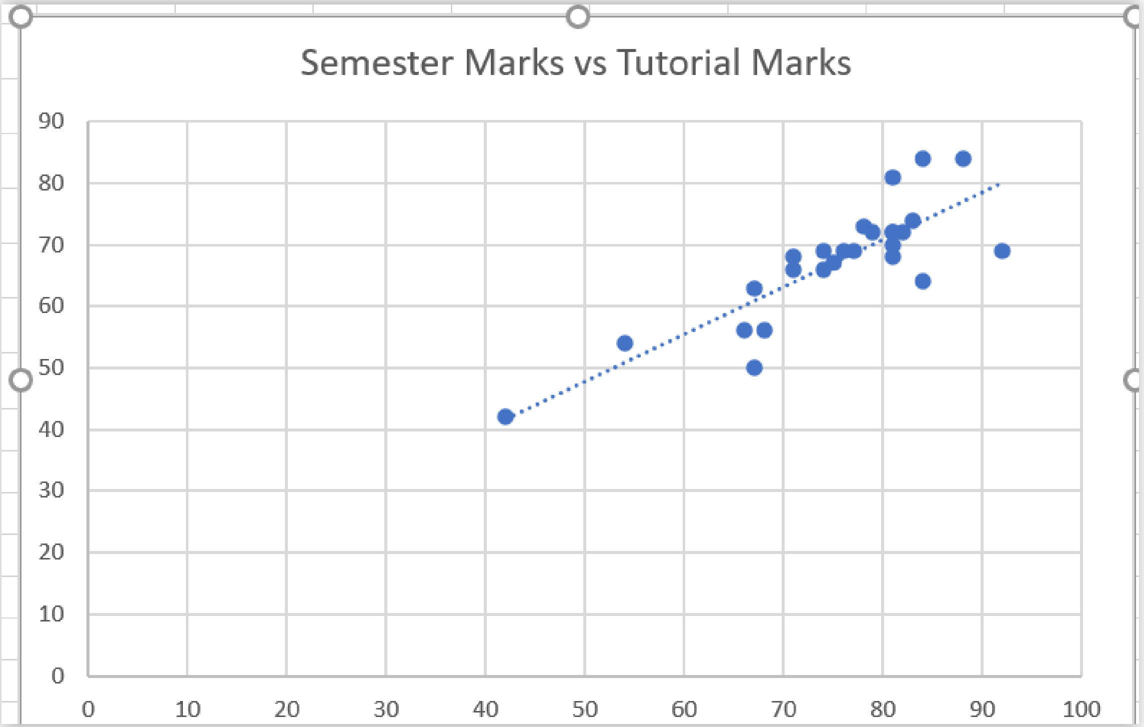
Research: Mathematical background and pre-calculus performance

- Concerns by CME (Concerned Mathematics Educators in 2008
- Study in 2009: Old Curriculum (9); New curriculum (11) and International curriculum (6)
- Doing B.Sc & B.Pharm (26)

- Relationship between mathematical background and actual performance in pre-calculus mathematics
- Factors that may influence students' performance in pre-calculus mathematics

	Group	Marks (in tutorials)	Marks in semester exam
1	Old	84	64
2	Old	74	66
3	Old	92	69
4	Old	81	70
5	Old	79	72
6	Old	75	67
7	Old	81	68
8	Old	42	42
9	Old	68	56
10	New	78	73
11	New	66	56
12	New	74	69
13	New	81	81
14	New	82	72
15	New	67	50
16	New	67	63
17	New	81	72
18	New	83	74
19	New	71	66
20	New	77	69
21	International	81	72
22	International	54	54
23	International	84	84
24	International	76	69
25	International	88	84
26	International	71	68

Marks obtained in tutorials and exam



Positive correlation between tutorial test marks and semester exam marks

ANOVA analysis: The mathematics curriculum followed at school, had no effect on their performance in the tutorial tests.

There are other factors or influences which played a role in the way the students performed in the module.

ANOVA analysis: statistically no significant differences among the three groups in their final examination marks for the semester.

Factors influencing performance

- Positive attitude to mathematics: Help them in their degree studies; subjects such as Chemistry and Physics
- Mixed methods of teaching: Class discussion; working in pairs and sharing; lecture type; question and answer; problem based learning; use of slides
- Challenging but enjoyable module: Consolidation of what they learnt at school; learning new content; problem solving skills
- Well structured study guide: Exercises at the end of each chapter – self-study; consolidation and working ahead
- Competitive class spirit: Any student could do well in the tests
- Student determination: 21 out of 26 got more than 60% in exam; 3 Science students did well in all subjects; moved to Pharmacy

Research: Problem Solving

Can pre-calculus students' competence in solving "word problems" be improved through structured classroom intervention?

- Approximately 45 Students in sample: 29 Engineering; 16 Analytical Chemistry
- Action research model (Kemmis and McTaggart (1982), cited in Townsend (2010:138)
- Word problems - Problem solving

Problem solving abilities of students

- Good at doing algebra; not able to apply to problem solving
- They had difficulty with understanding the words and being able to translate the words into appropriate equations; further support needed
- A follow up survey confirmed the suspicions of the writer that these word problem-types are given very little or no attention at school.
- For many of the students, this was their first encounter with such word problems.
- They found the session difficult but useful as they believed that being good at problem solving would definitely help them in their future careers.
- In the second session, hints were given to direct the students' thinking and reasoning. This led to significant improvement in two of the three questions.

Numerical Skills in nursing

- 50 participants
- Mathematics background: influence on experiences and reflections
- Experiences of the module and their learning from module
- Performance in module

Mathematical background

- Easy for those who did Mathematics at school
- Mathematical Literacy: familiar; coped well; struggled with problems requiring “abstract” mathematics
- Those without mathematics – struggled; had to work hard

Experiences of the module

- Well received
- Mixed method teaching
- Study guides and workbook exercise – well constructed and user-friendly
- Mathematical skills and concepts learnt; could not wait to apply these during their practical training
- Regular tutorial and semester tests – reflect on their strengths and weaknesses

Findings (Nursing)

- Link between service module and field of study
- Carefully constructed study guide, with solved problems in context; number of exercises for consolidation
- Regular tutorial and semester tests
- Students are not “regular” mathematics students; variety of teaching methods
- Work in groups/pairs to share ideas and solutions with each other and the whole class

From school to university: Implications for teaching and learning:

Who are our students?

- Acknowledge our students; who they are; where they come from (and they deserve at university)
- What are their backgrounds and experiences?
- Do we expect “gaps” in their knowledge? How do we ascertain if there are gaps? How do we address any gaps?
- How did they do in Mathematics at school? Results are important but potential is even better
- What are their aspirations?

Implications for teaching and learning: Students in our classes

Students in our classes

- Why are they in our classes? Is it by choice or is it a compulsory requirement of their courses/ programmes
- How do we connect with them?
- What kind of experiences do we want them to have?
- What do we want them to gain from our classes?

Implications for teaching and learning: course materials/study guides

Course materials/study guides

- What type of course materials are we using?
- Is the course material relevant, contextual and up to date?
- Is the course material available in a coherent, well structured study guide (in hard copy/electronic copy)?
- Are there opportunities for students to do self-study/independent learning?

Implications for teaching and learning: Lesson delivery

Lesson delivery

- What type of teaching approaches do we use in our classes? Lecture/Class discussions/Group work/Power-point slides/mixed mode (Blended learning)
- Online/virtual teaching
- At what pace do we teach?
- Do we allow for students' questions?

Implications for teaching and learning: Assessment

Assessment

- What type of assessments do we have for our courses? Projects/Assignments/investigations, short tests, longer (semester tests), online assessments; examinations
- How do we support those who are "not coping"? Is this from classroom observations or from test marks or have students have approached lecturer? Extra tutorial sessions, study groups, remedial teaching; additional useful references (may help)

Conclusion

- The transition from high school to university is quite an enormous one; intimidating
- Change of environment – from a protected one to an open one; how do our students manage this change?
- Preparing students for success in their studies and thereafter the World of Work (and developing our country) where they are likely to use/require mathematics at different levels
- How are we contributing to this important part of our mandate? I hope I have shed some light on this matter

Thank you