A comparison of introductory mathematics modules within a mathematics programme and an economics programme

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My Background

- I am an academic member of staff of the University of Birmingham School of Mathematics, UK.
- I am also a visiting professor at Jinan University, Guangzhou, China.
- During the previous 7 academic years I have taught a first year linear algebra course to (nowadays) ≈ 270 students in year 1 at the Jinan University - University of Birmingham joint institute.
- I've also taught Real Analysis and Calculus for a few years at the J-BJI.
- Students are enrolled on 4 joint honours dual-degree programmes (with Applied Mathematics as a core component).
- One of these is a BSc programme in Applied Mathematics with Economics.
- I also supervise PGT students in dissertations which can focus on mathematical modelling in relation to economics.

Outline

Motivation

As the student body in many undergraduate Economics courses can be international and otherwise diverse, course leaders need to think about specific help for students to deal with language issues, mathematics support (as use of mathematics might be quite different from the focus in school), and study and exam skills support. These issues are present in any degree course, but Economics may pose a particular challenge since its study at undergraduate level is quite different from that at school-level, for those who have taken the subject before.[1]

[1] See 3.10 QAA, Subject Benchmark Statement, Economics, 2023.

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Question - Is there a difference in conceptual difficulty of mathematics assessments at upper secondary level and lower tertiary level?[3]

[2] See 3.10 QAA, Subject Benchmark Statement, Economics, 2023.

[3] See Kinnear et al., Teach. Math. Appl., 39(4), 2020 and E. Darlington, Teach. Math. Appl., 34(4), 2015.

Related Literature

- Classification schemes for Mathematics questions
  - MATH taxonomy[4]
  - Alternative Schemes[5]
  - MATH taxonomy applied to level 2 and 3 math.[6]
- Reading Mathematics:
  - math text vs non-math text [7]
  - Word problems in mathematics education[8]
  - Uncommon words in mathematical tasks[9]

[4] See Smith et al., Int. J. Math. Educ. Sci. Technol., 27(1), 1996.
[5] See the review article B. Scheja & B. Rott, Math. Educ. Res. J., 2024.
[6] See Kinnear et al., Teach. Math. Appl., 39(4), 2020 and E. Darlington, Teach. Math. Appl., 34(4), 2015 and J. C. Meyer et al., in prep., 2025
[7] M. Österholm, Ed. Stud. Math, 63, 325-346
[8] See the review article L. Verschaffel et al., Zdm 52(1), 2020.
[9] E. Dyrvold, et al., Nord. Stud. Math. Educ. 20(1) 2015

The MATH Taxonomy

Group	Outline	Subgroup	Description
A	Factual recall & routine procedures	FKFS	Factual knowledge & fact systems
		COMP	Comprehension
		ROUP	Routine use of operations
B	Using existing mathematical knowledge & techniques in new ways	IT	Information transfer
		AINS	Application in new situations
C	Application of conceptual knowledge to construct mathematical arguments	JI	Justifying & interpreting
		ICC	Implications, conjectures & comparisons
		EV	Evaluation

Table: The MATH taxonomy as presented in E. Darlington, Teach. Math, Appl., 34(4), 2015.

Summary of Exam data

Exam	Papers	Total questions	Total marks
VGLA	7	254	754
RAC	6	265	814
Gaokao	6	175	920
ME & IME	3	104	300
	22	798	2788

Table: Summary of the exam data considered in this presentation. For VGLA, RAC and Gaokao, A. Zhang, G. Zhao and S. Li contributed to data processing and A.Zhang and G. Zhao contributed to the project write-up.

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How was the MATH taxonomy applied?

Summary of MATH classifications

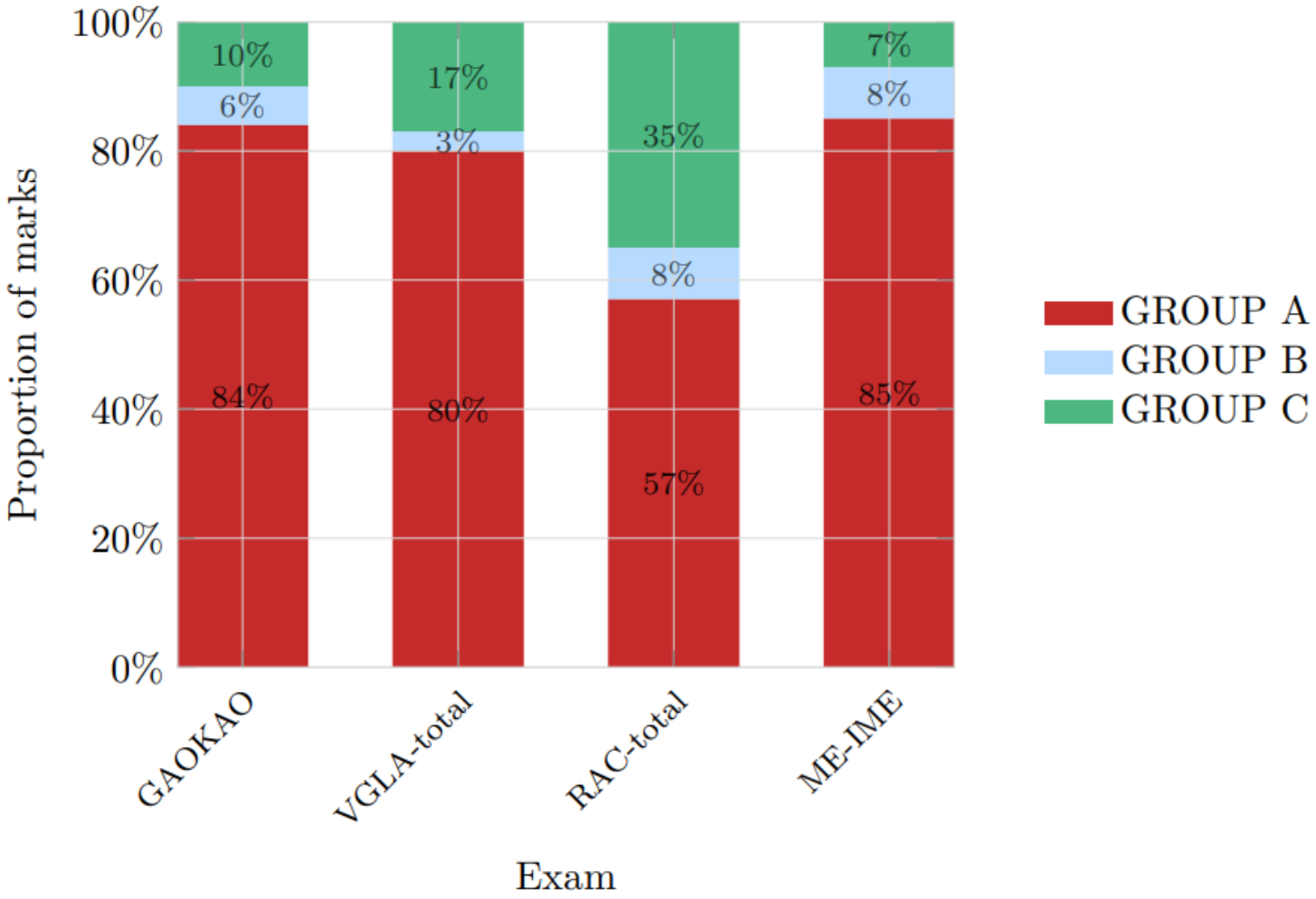


Figure: Mean percentage of marks in each exam MATH group.

Vectors, Geometry, and Linear Algebra

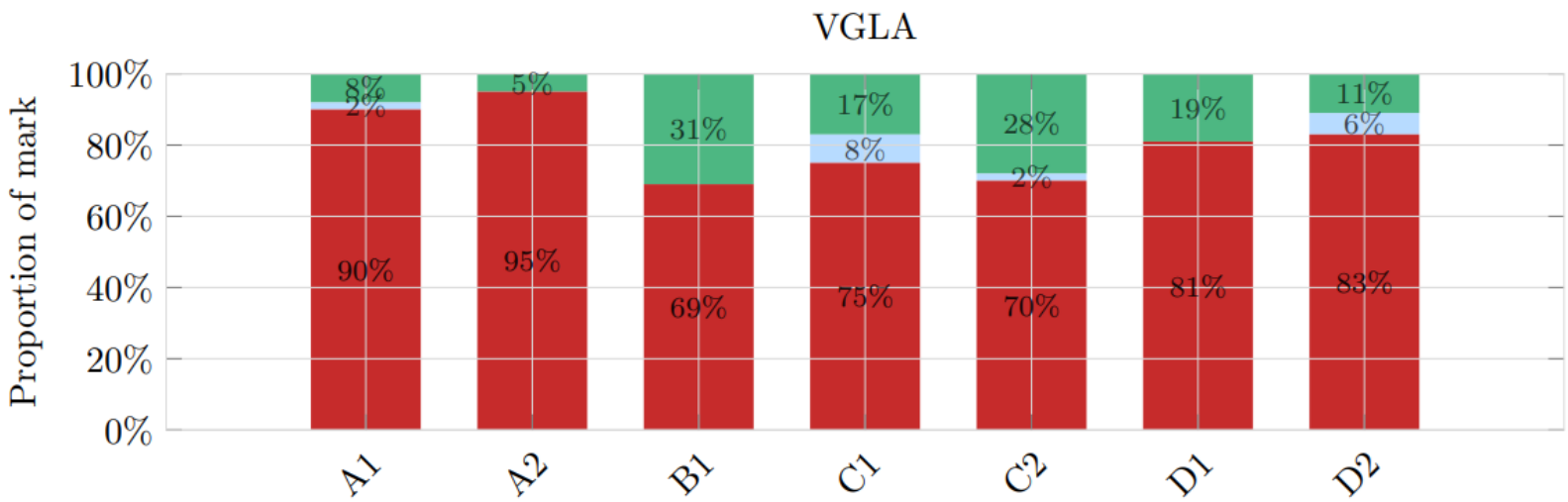
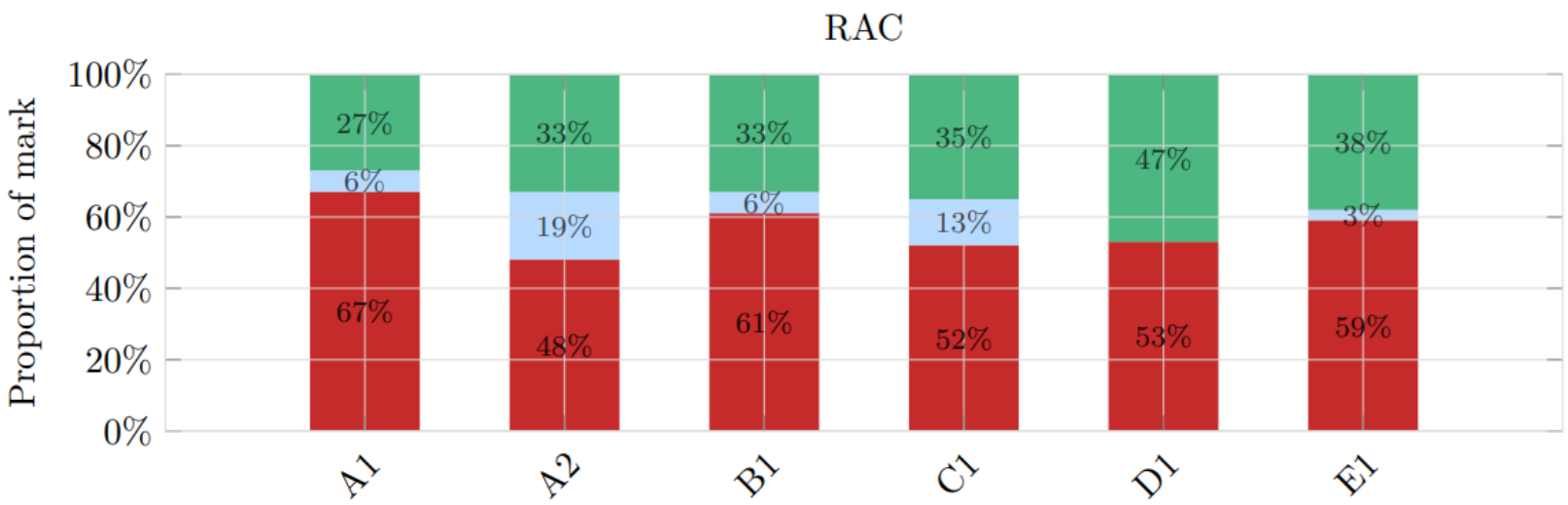


Figure: Percentage of marks in each MATH group in each exam paper

Real Analysis and Calculus



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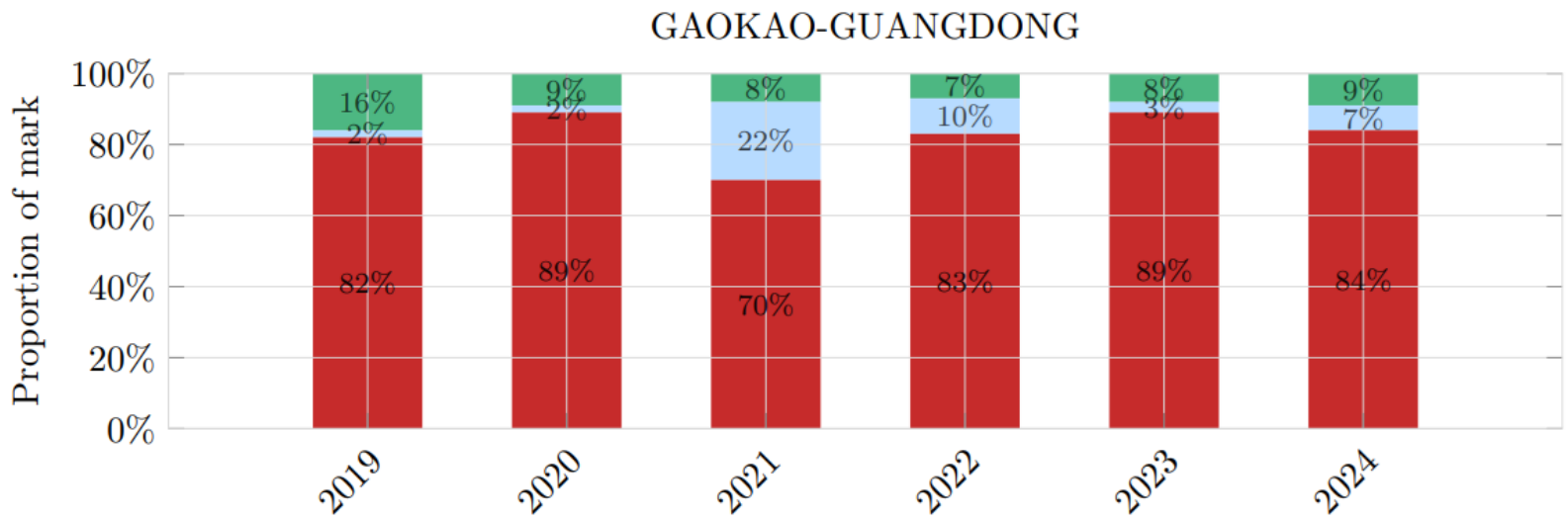
GAOKAO Math



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VGLA Component Structure

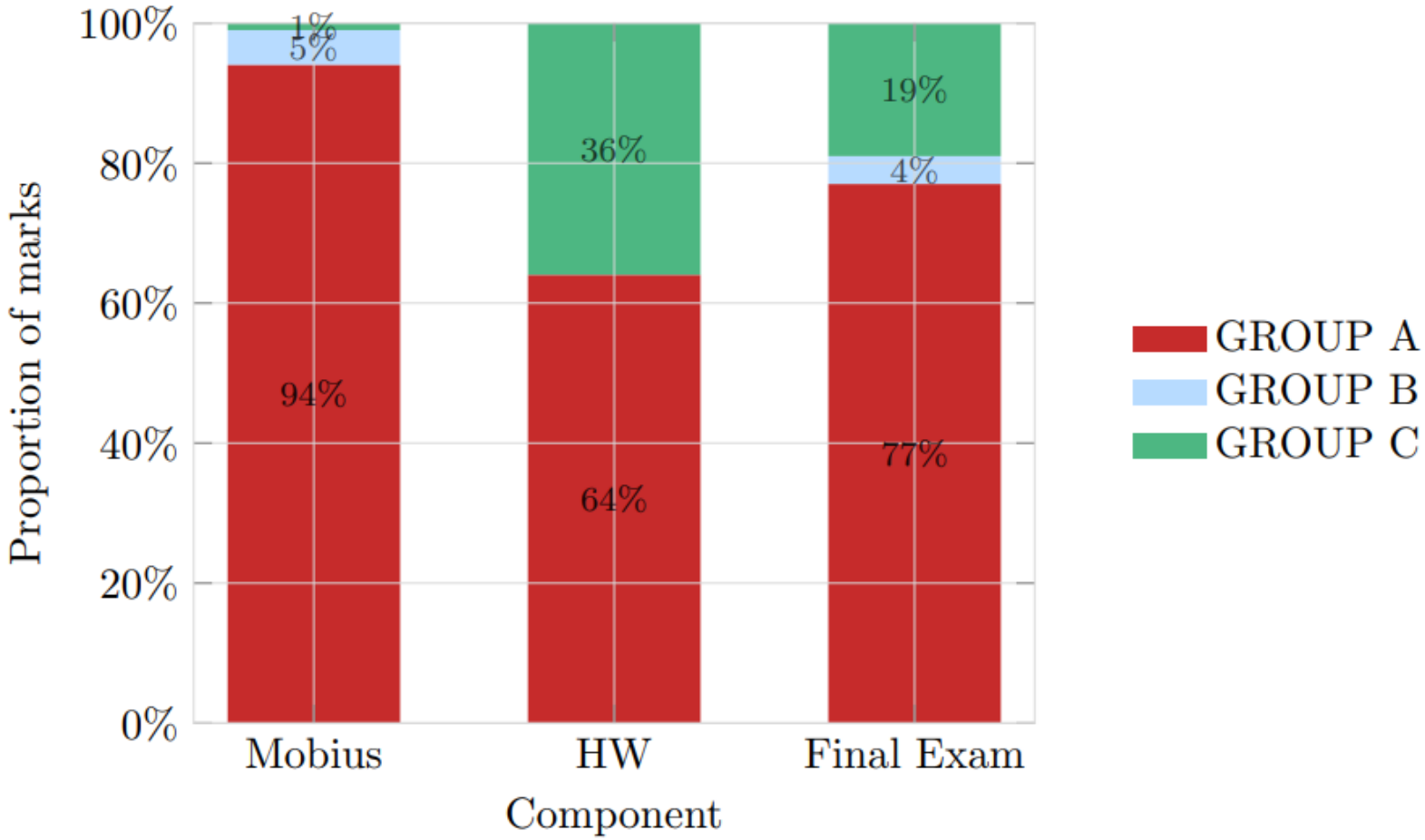

Figure: Proportion of marks in each MATH group for the three components of assessment in J1VGLA

ME & IME Component Structure

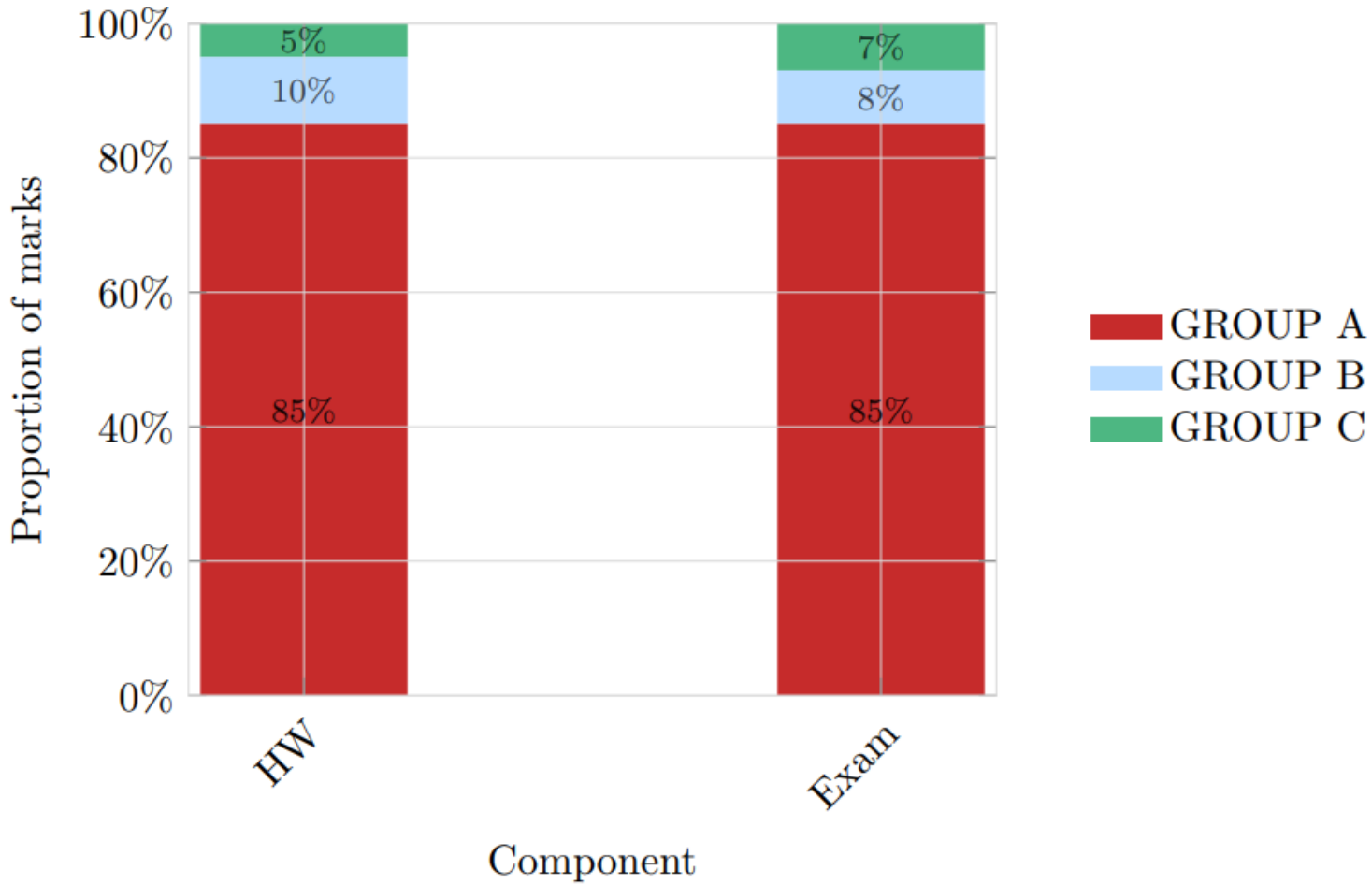

Figure: Proportion of marks in each MATH group for the two components of assessment in ME and IME.

Proofs...

Standards above the threshold may be demonstrated through: ... the student's ability to construct and present a reasoned argument or proof and how far the student can progress through it ...[10]

[10] See 4.8 in QAA, Subject Benchmark Statement, Mathematics, 2023

VLE Module Resources

Some brief reflections on module resources for ME & IME with VGLA and RAC.

- Lecture Notes - ME & IME use economic applications to a greater extent; have less emphasis on proofs; and, are potentially a bit less concise.
- Practice questions - ME & IME have: a large (good) volume, similar to VGLA (more than RAC); less emphasis on rigour than VGLA and RAC; and cover a range of conceptual depth in questions.
- Seminars - Used quite similarly, to address predictable topics students find difficult.

Language in Exams

- Informally, it appears that a small number of ME & IME exam questions are more challenging to read than others.
- This may negatively affect students who don't sit the exams in their first language.[11] That is in relation to them demonstrating they have met learning outcomes.
- There are various measures which one can use to quantitatively test this observation. For example the 'readability scores' attributed to Flesch-Kincaid, and, Fry, etc.[12] can potentially be used.

[11] At UoB English entry requirements differ for Economics and Mathematics UG programmes. Also see F. Theens, Diss. Umeå Univ., 2019.

[12] See E. Fry, J. Read., 33(8), 1990.

Language in Exams

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[13] See 3.10 QAA, Subject Benchmark Statement, Economics, 2023.

Additional Considerations

1. Apply the MATH classification to more ME or IME exams.
2. Select an appropriate & feasible quantitative approach to measure the complexity of exam question text, and apply it to VGLA, RAC and ME & IME exams.
3. Investigate whether an Economics-specific version of the MATH taxonomy would be of value.
4. Investigate whether MATH classifications exist in the literature for course content from UG Mechanics, and, A-level Economics.

Thank you for your attention.

Please feel encouraged to comment or ask questions?