The Minerva Project: Investigating Student Mathematical Preparedness for Science and Engineering at University

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IOP Higher Education Group Regional Community Meeting

London 26 November 2018

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Background

- High drop-out rate from first year (Coertjens et al., 2016). Science and engineering degrees have a very high rate of student attrition (Malm et al., 2013; Ulriksen et al., 2017)

- Student progression and retention is now a national priority in Irish Higher Education as enrolments increase (HEA, 2016)

Rationale

- The overall rate of non-progression (from year one to year two) was 11% for level 8 degrees in universities in the year 2012/13 (HEA, 2016).

- Prior academic achievement has been found to be the strongest predictor of non-progression in higher education (HEA, 2018).

- Strong rationale for investigating students' transition to university, particularly for students enrolled in STEM degrees.

School Learning

- Many reasons for student difficulties transitioning into third-level, but mathematical knowledge crucially important for science and engineering (HEA, 2018)

- First-year physics and engineering undergraduate students perceived physics and mathematics as quite separate subjects; with little crossover (IOP, 2011).

- Mathematics and science subjects often not taught in an interdisciplinary fashion (STEM) at school (Czerniak & Johnson, 2014).

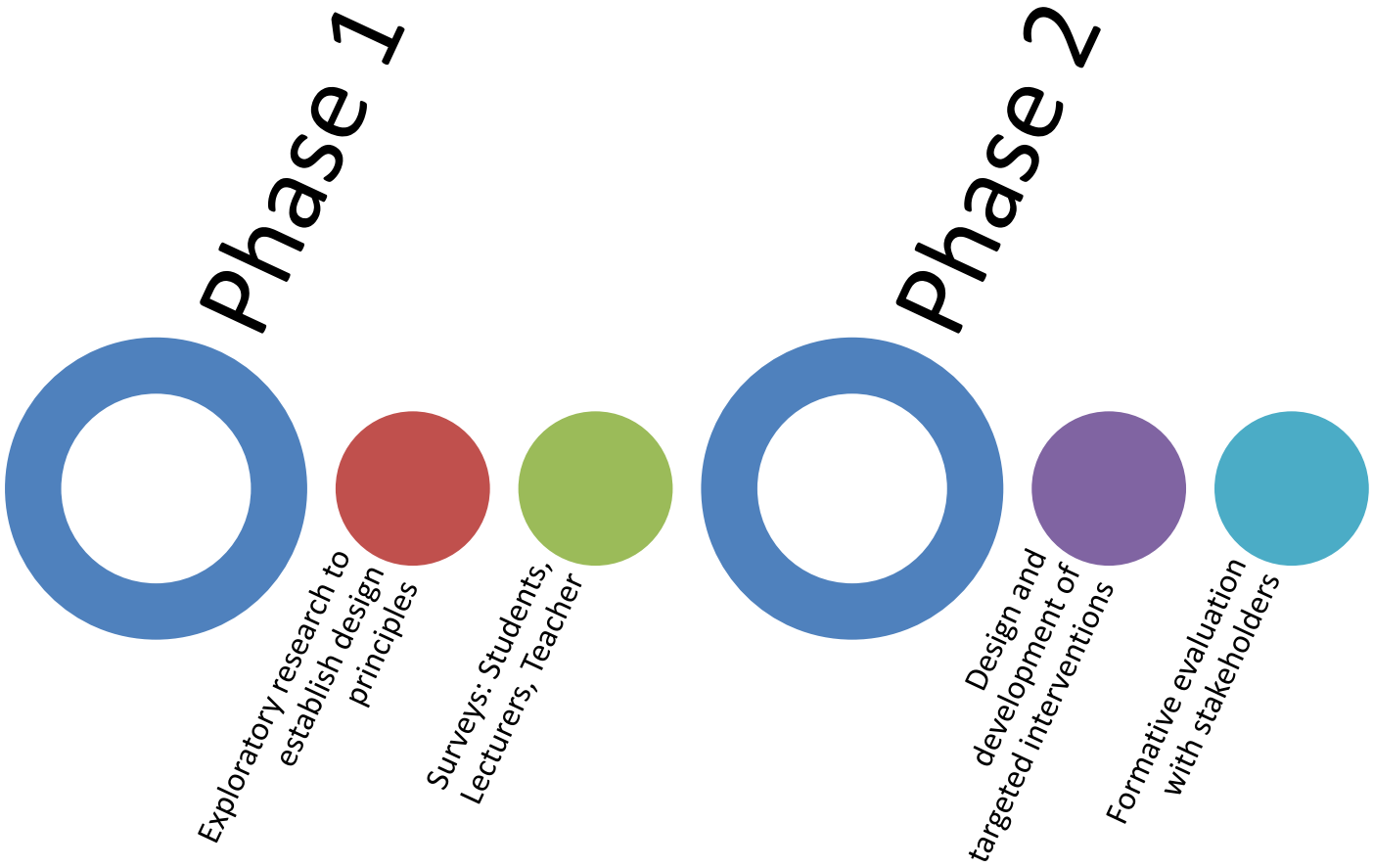
- Maths teachers often unfamiliar with science subjects, and vice versa for science teachers – reluctant to integrate (Walshe, Johnston, & McClelland, 2017).

Science Learning Centre

- Approx 4000 student attendances 2017/18
- First year physics modules, chemistry modules and engineering modules
  - One to one Drop-in
  - Support tutorials
- Now focusing on developing targeted supports to support students in transition

Aims of Study

- To gain a multi-faceted understanding of the extent to which student learning of mathematics and their experience of interdisciplinary STEM education in secondary prepares them for University.
- To design supports to address any gaps identified in student mathematical preparedness



Methodology is Educational Design Research, characterized by iterative design and formative evaluation of interventions in complex real-world settings. Working with all stakeholders to inform, design, pilot and refine the elements of an educational intervention is central (Plomp & Nieveen, 2013).

Research Questions for Phase 1

- What are teachers, lecturers and first year students' perspectives on the level of mathematical preparedness of students for science and engineering degrees?

- What understanding do teachers, lecturers and students have of STEM education, and in particular, integrated approaches to teaching STEM subjects?

- Does social media indicate that networks exist that connect various actors across second and third level, such that the students' process of mathematical preparedness might be enhanced?

Questionnaire Focus

Questionnaires aim to determine the target groups' understanding of STEM education and interdisciplinary teaching

- Teachers' views' on their role preparing students for third level education, and their familiarity with third-level STEM courses
- Lecturers: level of knowledge of school science and mathematics subject curricula; relevance of mathematics to first year modules; any gaps
- Students: educational qualifications, attitudes towards physics and mathematics, relevance of school mathematics to first year physics/engineering; top topics/gaps

Student Questionnaire Responses (Oct/Nov 2018)

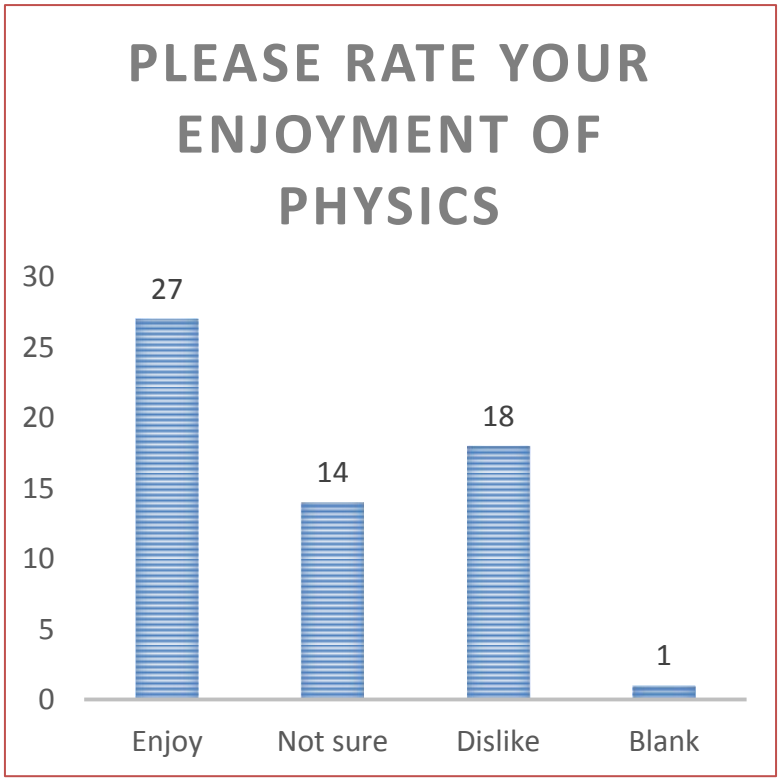
Physics Module 1: n = 104

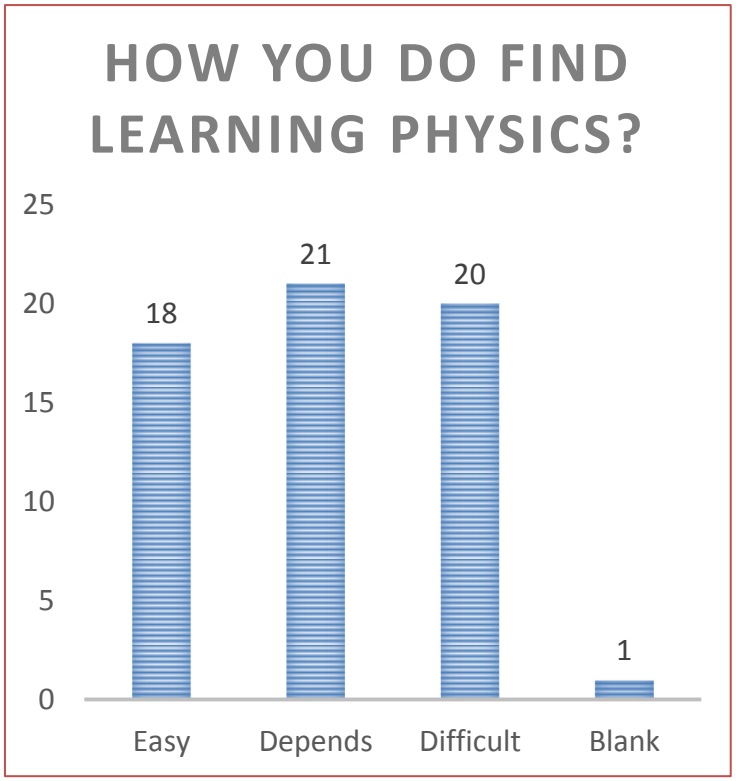
Physics Module 2: n = 22

Engineering Module 1: n = 160

Two Simple (too simple?) Questions

Purposive sample of 60 responses





Some connections

Enjoy physics and find it easy to learn:

-Have studied Physics, and HL Maths at school

- Think school maths is really useful in learning physics

Dislike physics and find it difficult:

- Have not studied Physics, but have studied HL Math
- More likely to think school maths is not much help learning physics

Conflicting perspectives

‘[HL school] maths covered the topics included in my modules’

‘Physics maths is harder than any maths I've done before’ (Has done HL school Maths)

‘The physics we do is very maths and problem solving based. The chemistry maths is the same as the [school] maths for chemistry’

‘Start from the very start and explain what each letter in a formula corresponds to.’

Preliminary Thoughts

- Students new to physics have conflicting views on their mathematical preparedness
- Need for this group to be supported with Trigonometry/Vectors, but not just techniques
- To move beyond ‘plug and chug’ approach
- Critical to engage future teachers
- Bridging gap between secondary and university level and across subjects/disciplines

Thank you

References

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