STEM GC Future UG STEM Education

Scope and process

Scope: Obtain ideas and contributions from a range of departments and use this to give focus to the future discussions. Ideally want to obtain a "Venn diagram" of ideas to establish what departments have a consensus on and what are unique and specific needs for the future UG STEM education of their students.

Process: Liaise with departments by using our connections to each of the key departments within our group to survey and collect data as they see appropriate to get a department specific answer to the following key questions around two areas: (i) Existing STEM UG provision and (ii) New STEM UG provision.

Existing provision

1. **Defining disciplinary excellence**
   (a) What do we perceive as disciplinary excellence in education within your department?
   (b) What are your UG programmes known for?
   (c) How do you measure disciplinary excellence in your department? For example, recruitment numbers, league table performance, NSS metrics, employability, innovative content/learning activities or other?
   (d) What are your 'signature pedagogies' in your UG provision for developing disciplinary and transferrable skills?
   (e) What are the beacon courses/activities within your department?
   (f) What are the key selling points (attractions) to your programmes?

We believe that undergraduate study of physics should ask students to explore deep questions about the nature of the Universe and develop useful skills.

We aim to provide a supportive and friendly environment in which to study. This is how (we hope) we are perceived. Students should learn by working through exercises and problems not just from lectures and laboratories or from other formal elements of the curriculum. Interacting with others on the course, research students and friends from outside physics, are important pedagogical elements and we should facilitate these.

Our curriculum requires everyone to study the fundamental principles and to develop their core skills. After their first year, they choose which phenomena to study in greater depth and which skills to develop further. This flexibility is part of what makes our physics courses attractive to students and allows us to run our joint honours course with Mathematics, which we also consider a good training for theoretical physics. We introduced the course Physics with Astrophysics in 2020. This appeals to a traditional market in astrophysics. However, we are slightly unusual amongst non-Oxbridge universities for not running other separate courses concentrating on particular or niche areas. We see this as a strength and would not want to plan further joint or specialist courses without serious thought, as we need to protect our core education business.

Physics teaching is oriented around problem solving, helping students to think and approach questions in different ways. This is valuable for students in their careers, whether these are in physics or outside.

The principal metrics we look at are recruitment of undergraduates (numbers and A-level grades or equivalent), employment of graduates and external opinion - principally the external examiners and past graduates. We also monitor existing student opinion.

2. **Enhancing disciplinary excellence**
   (a) Have you identified any educational shortcomings in your UG provision?
   (b) How can the disciplinary excellence of your department's UG provision be enhanced? Bring specific examples e.g. offer a more balanced curriculum, increase learning by doing and experiential learning, improve industry collaboration and relevance to market needs, enhance alumni connections, improve student work experience, enhance curriculum to cover immersive technologies, adopt digital learning etc.

We believe that our courses have evolved into a strong and well-balanced offering. Where problems arise (response to Covid, increases and decreases in recruitment to different courses, poor examination results), we try to anticipate these and respond as quickly as possible.

We are reluctant to make substantial changes to the structure of our physics curriculum – we need to equip students with enough of the basics that they can become skilled physicists if they want this. We already limit some of the different areas of physics, that we teach, in order to fit in with timetabling requirements and student demand. Innovation in our curriculum is concentrated on the development of later year options (but only to replace existing modules and not to add more) and the development of skills modules (computing, final year research projects for example) to adapt to changes that happen in the real world.

Our delivery will evolve. In some areas we are not always able to take full advantage of all useful technology to support teaching. Sometimes there are limit set by the resources available. The result is usually a compromise work-around solution.

The physical space that we have available has not kept pace with the growth in student numbers. Teaching laboratories are cramped at times, which does not create a relaxed learning environment or a space where support can easily be provided to the students.

We have been using interactive and online learning for decades now. Our approach is: Try things out and keep those that prove helpful and are well-received by students.

Two of the most successful departments in recruitment terms in the science faculty (Maths and Statistics) are running very similar curriculums to the ones they ran in 1984. This is an attractive feature. We suspect that it reflects the idea (in science at least) that the results are universal and will last forever. In a hundred years' time, physics students will still study Newton's laws, thermodynamics, quantum theory as they do now. Understanding of phenomena will grow, but the place for us to cover that in our teaching is in final year options, once students have developed their understanding of fundamental principles.

There are advantages to improving engagement with industry, as it helps to confirm that we are teaching the core skills that graduates require and it can help with employability. Thirty years ago, the Physics Department probably had stronger and wider links with industrial partners (often through alumni). It was able to offer more student placements and more options of employment to our UGs. Strengthening industrial links would enhance the course and would benefit graduate employability.

3. **Improving shared STEM provision**
   (a) Can you identify any STEM themes/modules/activities (e.g. Big Data, Analytics, AI, Sustainability) from your departmental discipline-specific content that could be consolidated, co-located and/or shared at Faculty or University level?

We suspect that mathematically able students are attracted to studying the foundations of physics rather than the issues of the day. They see that the leaders in areas like Big Data, AI, Analytics and Sustainability, are usually people with pure science or engineering backgrounds, who have come from somewhere that has disciplinary excellence.

The nature of many of the current modern challenges or hot topics, is such that they are often best tackled by teams, with experts in different subject fields bringing different specialist skills, and by people who have a solid background in a science. These people and teams can pivot to work on different types of problems.

The danger of heavily investing in some specialised activities rather than core disciplines, is that activities change with time – some disappear. In the years to come for example Big Data is likely to be considered just data.

Interdisciplinarity

PX has a joint course with Maths (and some overlap with Stats) and one minor programme with WBS (both of which we have been running for decades).

Our timetable is full, so that supporting new outside modules almost always means degrading our existing timetable. This gives a worse experience for most of our students for the benefit of a minority.

Percentages of students' modules taught by different departments in 21/22:

Students	MA	PX	IL	CS	ST	IB	IE	PH	EC	ES	LL	CH	EP	GD
Maths	**78.3**	3.52	0.29	1.97	6.82	2.11	0.00	2.53	1.88	0.07	1.89	0.01	0.42	0.03
Physics	15.9	**81.1**	0.13	0.21	0.38	0.94	0.00	0.44	0.00	0.03	0.64	0.00	0.26	0.05
Stats	23.0	0.15	0.05	3.70	**44.9**	14.7	0.00	0.58	11.7	0.01	0.98	0.02	0.16	0.00
CS	5.62	0.38	0.11	**86.7**	0.73	1.31	0.00	0.24	0.04	3.13	1.68	0.03	0.00	0.00
CH	0.00	0.66	0.41	0.00	0.00	0.45	0.00	0.03	0.00	0.00	0.80	**97.37**	0.36	0.00
ES	0.00	0.00	0.00	0.13	0.00	0.92	0.00	0.00	0.00	**98.39**	0.53	0.00	0.04	0.00

Like departments in mathematical sciences, we allow students to take almost any module across the University via the unusual option scheme. When sufficient interest in some outside module develops, we would look at protecting that module in the timetable. The figures above show the percentages of students' modules taught by different departments

for students homed in the departments MA, PX, ST, CS, CH and ES and give an indication of which interdisciplinary areas are of interest to science students.

4. **Improving employability and skills for the workplace**
   (a) Can you identify any Departmental, Faculty and University UG modules/activities for skills development and employability?
   (b) Can you identify UG modules/activities to consolidate and co-locate at Faculty and University levels for employability/skills provision to maximise accessibility and engagement for students and complement departmental provision?

Skills need to be learnt not taught. Our emphasis is on modules and activities which allow students to develop skills to the level, and at the pace, they need.

What tends to work for physics students are modules which have clearly been developed by people, who have completed physics or mathematics degrees. Often people without these backgrounds, who develop general modules, have stereotyped views of what physics students are like. Now that intakes in most STEM departments are so large, it makes more sense to us to develop modules at the discipline.

University-level or even Faculty-level modules do not seem to go down well with physics students. For example, the WOLC and Warwick Skills award have not been well-received by physics students.