

Date: Wednesday 22nd June 2022
Time: 10:00-11:00am
Venue: Online via zoom
Resources: [Available here](#)

MINUTES:
Realigning Curricula For the Future: Mathematics and Sustainability

Attendees:

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| Gavin Rees | GR | Glasgow Kelvin College |
| Tracy English | TE | Fife College |
| Rose-Marie Murphy | RM | Fife College |
| Ian Strachan | IS | University of Glasgow |
| Tim Hughes | TH | University of Exeter |
| Elaine Hewitson | EH | Dundee and Angus College |
| David Jordan | DJ | The Univeristy of Edinburgh |
| David Borchers | DB | University of St Andrews |
| Bernd Schroers | BS | Heriot Watt University |
| Lucy Patterson | LP | EAUC |

| Time (mins) | SUMMARY OF DISCUSSIONS | ACTIONS |
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| 0.00 | <p>Welcome, Apologies and Introductions</p> <p><i>Lucy Patterson, Sustainability in the Curriculum Project Officer, EAUC</i></p> <p>Everyone was welcomed to the event and speakers were introduced:</p> <p>Bernd Schroers- Bernd is entering a transition from his role as a Professor of Mathematics in the School of Mathematics and Computer Science at Heriot-Watt University to his new role at The University of Edinburgh as Head of Mathematics in just a few weeks. He brings with him a wealth of experience embedding sustainability in the mathematics curriculum as he delivered both courses tying mathematics to sustainable energy and climate science.</p> <p>David Borchers- David is based at University of St Andrews where he is Director of CREEM (Centre for research into ecological and environmental modelling). Prior to this he was Head of Statistics and had a leading role developing a masters in Statistical Ecology which features many themes of sustainability.</p> <p>Attendees were then invited to introduce themselves:</p> <p>Ian Strachan- Head of school of Mathematics and Statistics at University of Glasgow</p> <p>Tim Hughes- Moving from Mathematics to Earth and Environmental Science department at University of Exeter. Lecturer in applied data science, have some courses with environment sustainability and Renewable Energy themes.</p> <p>Gavin Rees- Lecturer in Math at Kelvin College</p> <p>David Jordan- Director of sustainability in the School of Mathematics at The University of Edinburgh. Will be working with Bernd on Curriculum transformation.</p> <p>Elaine Hewitson- At Dundee and Angus College in the essential skills team mostly teaching math and numeracy.</p> <p>Rose-Marie Murphy- Works at Fife college as mathematics lecturer.</p> <p>Tracy English- DYW co-ordination at Fife College</p> | |
| 7.36 | <p>Case Study</p> <p><i>Bernd Schroers, Professor of Mathematics, University of Edinburgh and Heriot-Watt University</i></p> | |

A number of areas come to mind when thinking of mathematics and sustainability: Energy Numeracy, Carbon Numeracy, Climate Numeracy, Thermodynamics, Atmospheric fluid mechanisms, Statistics, Optimization of energy systems, Modelling and Computation, and Conceptualization. Bernd explored Numeracy and interdisciplinarity between Mathematics and history as key approaches to embed ESD:

Numeracy- He shared examples of how ESD can be embedded in numeracy through estimation problems that could begin discussions to instill a sustainability focused way of futures thinking in students. His late colleague, David JC MacKay's book called 'Sustainable Energy- without the hot air' has hundreds of order of magnitude calculations that are suitable.

History of local mathematics- Scotland's past mathematicians played a vital role in both causing and understanding climate change through invention of steam trains to work on thermodynamics. These same areas, thermodynamics and atmospheric fluid mechanics, can be turned round to transition to net-zero.

At University of Edinburgh they have a webpage dedicated to [sustainability at The School of Mathematics](#) showing areas where sustainability is embedded in curriculum, generally it is featured in modules across degree courses. At Heriot-Watt University they have more dedicated courses to sustainability such as thermodynamics and fluid mechanics. The African Institute for Mathematical Sciences have made effort to create dedicated programs at master's level around sustainability which Scottish institutions could work in partnership with to allow students to get hands on experience of mathematics impact in countries where climate change is felt most.

Questions

LP- You mentioned Heriot Watt has specific courses, how do you feel they compare to embedding sustainability more subtly throughout all courses such as at Edinburgh?

BS- I think they're different sides of the same coin, I think we need to do both. We shouldn't be shy in Mathematics to share we've got some real expertise to contribute and those are courses we should highlight to students. If you really want to understand global warming then of course the mathematics of thermodynamics would make you an expert and there's very few people who can access that knowledge, the way the sun heats the earth through radiation is a very complex process and is a wonderful thing to understand and teach. These courses might look a bit old fashioned because they go back to 19th century ideas but they now have a new and modern role and we should look at them, again from that angle. I was surprised

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| | <p>University of Edinburgh doesn't offer such courses at the moment and I would like them to encourage people to offer again. Certainly the AIM center have made these climate courses part of their core curriculum.</p> <p>IS- Firstly can you expand on how a school operates sustainably? Secondly can you explain the difference between introducing sustainability at the level of individual courses and at the program level as there are different scales there?</p> <p>BS- By operation I mean how we travel, how we entertain guests- the School of Mathematics in Edinburgh has a policy of only offering Vegetarian food when catering and that's done with an understanding of sustainability. Whether we allow travel abroad for short conferences. We are embedded in a way the university heats the building which is suboptimal, we currently have a combined heating and power system we would be much better to use a communal heat pump and that's a discussion we should involve students in. I like making these things authentic, that this is not just an academic topic, their expertise is actually needed right here to improve some of the operations. In curriculum Its always in the conversation, for example order of magnitude calculations we try to embed all the time and that could happen in any course but separate from that we should remember we have dedicated specialist expertise. We should highlight those courses as being relevant to sustainability, students don't currently think of thermodynamics as a subject that would make them an expert on climate science.</p> | |
| <p>22.58</p> | <p>Case Study</p> <p><i>David Borchers, Lecturer of Statistical Ecology, University of St Andrews</i></p> <p>David considered himself a scientist until his daughter told him he wasn't because he doesn't go out and find out things about the state of the world or the universe, which he admits is true. What statisticians do however, is develop the tools which other people use to find things out about the universe. This is what mathematicians contribute to sustainability. David showed some examples both studying sex discrimination in admissions at UC Berkeley using Simpsons Paradox, and another into salary at Yale University. Sustainability in the curriculum at St Andrews is about providing tools for people to pursue sustainability issues but most of their modules</p> | |

have not been constructed with sustainable goals in mind, (with the exception of an 'estimating animal biodiversity' module and 'modelling wildlife population dynamics' module). The following modules do however embed sustainability and specific SDGs: Design of experiments, population genetics, medical statistics. Mathematical oncology, Spatial Models and pattern formation in mathematical biology, and geophysical fluid dynamics. 2 years ago they launched a MSc in statistical ecology motivated by work with conservationist and managers at CREEM and there is a clear lack of quantitative skills. The degree is largely interdisciplinary and 70-80% come from biological or ecological backgrounds rather than mathematics and 30% are practicing scientists. Similar to Bernd, David sees the importance of real problems and the course has connections to industrial partners who provide them with projects and placements. A lot of the audience comes from less developed countries so finance is an issue but they have a number of scholarships and plans to run online to improve accessibility.

Questions

DB- A comment that struck me while Bernd was talking- at postgraduate level if not undergraduate level I feel there's a structural obstacle to integrating sustainability into mathematics. That is that mathematics departments are very separate from other departments- At St Andrews at least we have a department of sustainable development and a department of Biology but at the MSC level its quite difficult to integrate degrees across departments. I feel that the historic university structure and funding structure makes it difficult to be interdisciplinary. **The best way to involve mathematics in sustainability in my opinion is to have an interdisciplinary degree, I don't know what others think about that?**

DJ- We have a similar struggle, the University is interested in interdisciplinarity but at knuts and bolts of making that happen, filling seats, getting lecturers, lining up resources its very difficult.

BS- This goes beyond teaching, its in research, mathematics is often the supporting actor in projects. Sometimes that's fine it means we can interact very broadly and is probably easier at a research level than teaching level. But we can build courses with other schools but it takes effort. University of Edinburgh has got operational research focused on energy which is recognized as an expertise that is specifically mathematics that optimizes complex energy networks we'll be running in the future and there's no other expertise that does that in quite the same way. So I think there's a few areas where the leading expertise is mathematics but otherwise we need to teamwork and we need to build collaboration with other

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| | <p>departments, which has been done in other fields so it must be possible.</p> | |
| 32.56 | <p>Quick SDG Curriculum Mapping exercise <i>Lucy Patterson, Sustainability in the Curriculum Project Officer, EAUC</i></p> <p>Attendees were provided with worksheets in advance of the session to support this Quick SDG mapping activity. Individually, in silence, for one minute attendees were asked to consider how their curriculum addressed a specific Sustainable development goal starting with SDG 13- climate action, followed by SDG 1- No poverty, then SDG 6- clean water and sanitation. Where they do not currently address an SDG they were to consider how they could.</p> | |
| 43.39 | <p>Open Discussion</p> <p>TH- You named carbon numeracy as a potential gap. I wonder do you feel that is a gap and if the audience we should be looking for here are mathematics students or should we be looking to fill this quite broadly? Because I've seen a lot of carbon literacy training across institutions, and promoted by EAUC. So whether there is a gap there and whether there is an opportunity to make a community to help fill that?</p> <p>BS- I think there is a gap. I don't think that's proposing anything new here from carbon literacy and books like 'how bad are bananas' which estimates carbon footprints of activities, that's the kind of mental exercise that we should embed. It's good mental arithmetic, using powers of ten and converting units but some of the numbers involved are staggering and surprising and I think it's the kind of habit that mathematicians should be in. Order of magnitude calculation or example, calculating how big an impact something has in carbon terms is mathematically no different to estimating number of installers needed for decarbonizing domestic heating. So mathematically you can apply the same thinking across the board. But is gone out the window as its seen as too simple but students can't do it if you ask them to do it because it requires estimating things you can't look up exactly so accepting you can only get it right to powers of ten is an important skill. I don't know the connection between carbon numeracy and literacy, I guess literacy is more understanding concepts and numeracy is powers of ten. I feel that was missing in so many about climate change- that ability to quickly check the numbers. So I'm making a point of incorporating that at a</p> | |

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| | <p>basic level across lectures and advocating a culture of every lecturer doing order of magnitude calculations.</p> <p>DB- That relates to a general feeling or complaint I have about how teach statistics in particular. We teach very fine skills, in what you've formulated a problem how to do you solve the problem. What we don't teach is how to take a real world problem and formulate it mathematically. When you go out into the real world as a statistician is an absolutely crucial skill and it does relate to your problem of how we take something real and turn it into terms mathematicians are used to. So maybe not a direct sustainability issue but does look at how mathematics intersects with the real world.</p> <p>BS- Strongly agree with that, mathematics has a habit of starting a lecture with a definition, another definition a dilemma then a proof without ever saying what problem you're trying to solve. But we should start with the question. The African institute I mentioned, was created to address the problem of poor education at university level, and that's been a driving force there to always start with the problem then give them the tools to answer it better and better. It's true you start with the question then appreciate why mathematics is useful rather than other way around.</p> <p>IS- I have a question about the resistance of colleagues. Its easy to come up with new ideas of what you're going to teach then you're up against the question 'great idea what do you remove to make space for this new thing?' then you start getting resistance. So have any of you experienced resistance?</p> <p>DB- I personally haven't met resistance. The only overtly big change we made was the MSc degree, there were a few practical problems but no real resistance to it. How most of sustainability is embedded in our curricula is sort of almost invisible. We would put examples in the course eg. how sustainable is a windfarm and teach mathematical concepts through that. At that sort of small level no ones monitoring what particular example you use, its almost guerilla tactics for getting sustainability into the curriculum rather than structural. You presumably have met resistance, in what kind of things?</p> <p>IS- It's not that I have, there's lots of courses that could fall under sustainability area but they are existing courses so to move more to sustainability what new is needed to be done rather than changing</p> | |
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existing courses. The one thing that generates most is curriculum reform in schools because everybody has got their own ideas some of which aren't simultaneously correct and it's just the practicalities of wide scale change rather than tinkering at the level of individual courses which is easier to do. Changing a whole program is much harder to do and I'm trying to think of those different scales.

DB- In the instances where we have made structural changes finance has been crucial. To make structural changes we have to convince the University that this is going to be a new financial stream or improve student numbers. Once you can make that argument you get support of the center and that makes things much easier.

BS- There's no mathematics program that is going to be fully about sustainability but I think what it gives us educationally is a wonderfully motivating topic. So many parts of our syllabus suddenly become meaningful, nothing feels irrelevant which makes it more interesting to students. That would be my carrot for the staff it can help engage their students. The sustainability courses are where you focus because the link is more easily made and students find them very attractive so there's a pedagogical reason there as well.

DJ- Ian's question is an important one. We're thinking about the tactical challenges a lot right now at Edinburgh. One thing I found, I wanted to propose a course on operations research focused on sustainability for second year students but immediately hit resourcing issues and it happened that the facets of mathematics module Bernd mentioned was under review. It was meant to be an application focused course and the proposal from the director of teaching was lets just rework that. So we didn't have to push for new resources. One bigger thing where I feel we have the wind at our back is in hiring in the last five years or so, we seem to have hired a lot of people doing applied and operation research topics who already have some of this on their CV so that's making the job easier. For instance, the big ideas for these courses is coming from people who are enthusiastic about teaching them so it's a slow process but our colleagues feel its representing their interests so that's useful.

TH- I think a lot of this is through example, as Bernd said science caused a lot of the problems in the first place and a lot of those examples from problem applications are lingering so sharing good examples and making people aware and making it easy for them is best way to go about this.

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| <p>56.30</p> | <p>Thanks and close <i>Lucy Patterson, Sustainability in the Curriculum Project Officer, EAUC</i> We will set up a network after the session to maintain this network, please email lpatterson@eauc.org.uk to join or be removed from that.</p> <p>Final question to reflect on after the session and potentially pose to your students "How far do you think mathematics has the potential to mitigate climate change?"</p> <p>Thank you for coming, resources and recording will be available on the sustainability exchange.</p> | <p>Set up jiscmail list EAUC-RFSS-MATH @JISCMail.AC.UK</p> |

Minutes prepared by Lucy Patterson, EAUC-Scotland Sustainability in the curriculum Project Officer,
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