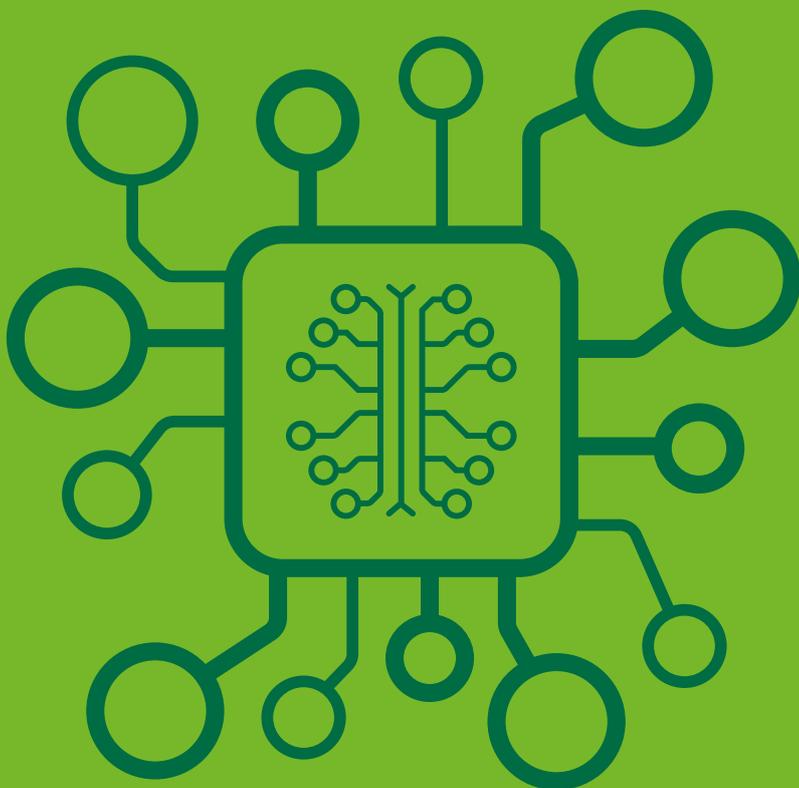


SCALING UP THE ETHICAL ARTIFICIAL INTELLIGENCE MSc PIPELINE

CREATING A DIVERSE, INCLUSIVE, SUBSTANTIAL
PIPELINE OF ETHICAL, COMPETENT AND TALENTED
MSc GRADUATES HIGHLY SKILLED IN MACHINE
LEARNING AND ARTIFICIAL INTELLIGENCE



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CONTENTS

Summary of key findings

3 BACKGROUND – HOW CAN WE BUILD AN ETHICAL AI SKILLS BASE?

What our top findings cover

What our conclusions cover

What are our top priorities?

4 CONTEXT AND OUTCOMES

How can this be achieved?

Scalable model

5 EMBEDDING ETHICAL STANDARDS INTO A1

The right skills

6-7 DIVERSITY AND INCLUSIVITY

Background

Student needs

Conclusions

8 BUILDING A PIPELINE FROM ARTS AND HUMANITIES

Background

Conclusion

9-10 CONSULTATION FINDINGS BEHIND OUR CONCLUSIONS

Employer demands and needs

University interest, capacity and capability

Conclusions

Ethical behaviours

The value of work experience

Scholarships

11 TEACHING INNOVATION AND SUMMARY

12 CONSULTATION STAKEHOLDERS

13 REFERENCES

HOW CAN WE BUILD AN ETHICAL AI SKILLS BASE?

BACKGROUND

The UK is world class at AI research, but we have a severe shortage of talented AI practitioners who can create AI products and services that will improve our prosperity and wellbeing. As well as producing AI PhDs who think up great new ideas, we need lots of skilled AI MSc graduates to take all those clever ideas and turn them into reality in every sector of the economy.

To address this issue, the Office for AI asked BCS, The Chartered Institute for IT, to provide an independent review of how the UK could produce enough MSc graduates with the requisite knowledge and skills to design, develop, deploy, manage and maintain AI products and services to meet the country's needs.

The government has recognised the demand for at least 3000 such MSc graduates every year based on its AI review [1].

This document is a summary of our findings, and key conclusions based on consultations, roundtables, and surveys. They are provided as independent advice to the Office for AI and its stakeholders, but do not represent their official position.

Our top findings cover:

- › Employer demands and needs
- › University interest, capacity and capability

Student needs

- › Ethical behaviours
- › Delivery models

Our conclusions cover:

- › Diversity and inclusivity
- › Models for MSc programmes that integrate professional development with academic excellence
- › Postgraduate skills evidenced against standards
- › Pipeline from arts and humanities

OUR FINDING

Synthesised in one sentence what came out of all the consultations, roundtables, and surveys:

Our finding: The top priority is creating a diverse, inclusive, substantial pipeline of ethical, competent and talented MSc graduates highly skilled in Machine Learning and Artificial Intelligence.

THE TOP PRIORITY IS CREATING A DIVERSE, INCLUSIVE, SUBSTANTIAL PIPELINE OF ETHICAL, COMPETENT AND TALENTED MSc GRADUATES HIGHLY SKILLED IN MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

CONCLUSIONS FOR HOW WE THINK THIS CAN BE DONE

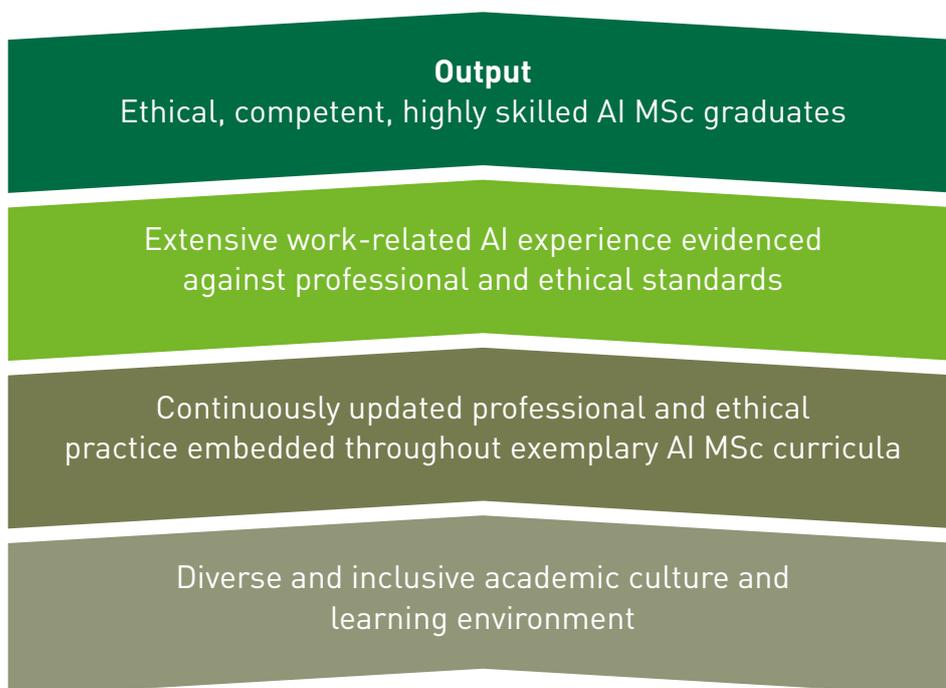
We came up with conclusions to achieve a scalable solution that delivers the top stated priorities outlined below. We have also included the major findings that shaped them.

Caveat: For our conclusions to work, it will require concerted collaboration from universities, employers, professional bodies, the Office for Students, Department for Education, the Engineering and Physical Sciences Research Council (EPSRC), the Office for AI, the Royal Academy of Engineering, the Institute of Coding, the Alan Turing Institute, the Centre for Data Ethics and Innovation and other relevant stakeholders.

HIGH LEVEL SCALABLE MODEL OF MSc PROGRAMMES

After consulting with employers, universities, government, students and expert bodies, we came up with the following high-level model, which is intended to be scalable and adaptable.

Conclusion: Ensure there are a wide range of MSc courses offered across the UK in Machine Learning and AI based on the high-level MSc model shown below, which provide students with extensive work-related experience that is evidenced and accredited against ethical and professional standards, including through degree apprenticeships at level 7 (which is a Masters degree equivalent) and MSc programmes with structured work placements.



High Level MSc model

DIVERSITY AND INCLUSIVITY

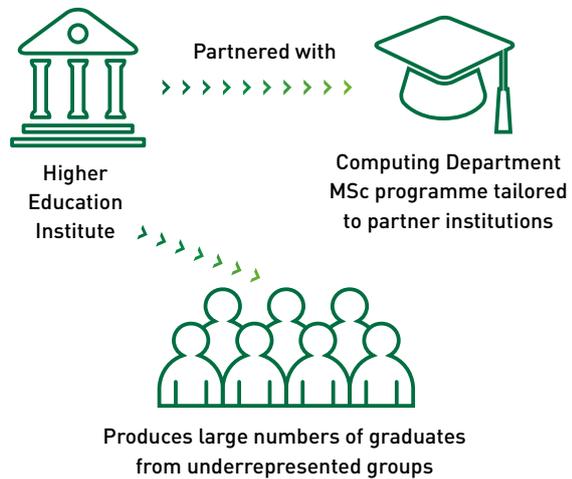
This is a problem across all of engineering and science, but this also means people have been thinking about this for a long time and evidence-based recommendations are starting to appear.

We include the main ones we believe will work for computing, which come from recent studies by the Royal Academy of Engineering [2] and the American Astronomical Society [3]; we've contextualised them for computing. These expert bodies have published other recommendations that should also be translated into a computing context, and wherever possible implemented.

Student Needs

Throughout the consultations held to inform our work, the lack of diversity and inclusivity in university computing departments has been raised as a priority issue that needs to be addressed.

In our view **every** computing student of whatever gender, ethnicity or social background is held back academically and professionally by a lack of diversity and inclusivity in the culture and learning environments of university computing departments.



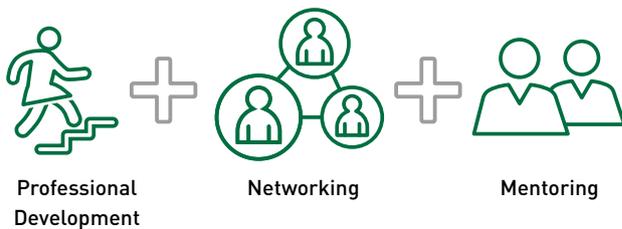
Conclusion: Develop excellence criteria to be included in inclusive postgraduate admission policies that take account of an applicant's potential to become an outstanding practitioner and consider a range of more broad technical skills beyond those particular to computing.

Conclusion: University computing departments should partner with, and recruit from, undergraduate programmes producing large numbers of female graduates and graduates from other under-represented groups.



Conclusion: University computing departments should ensure retention support for students is made inclusive by providing students from all backgrounds equal access to an extensive, high quality and properly resourced range of professional development, networking and mentoring opportunities.

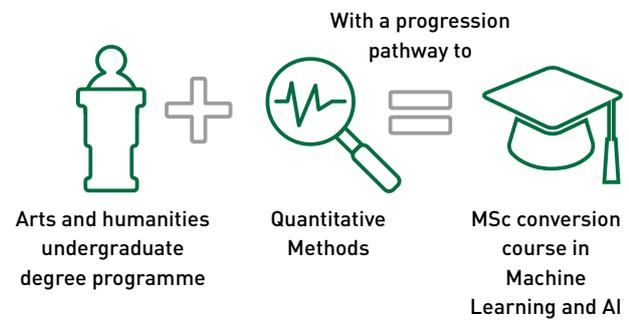
Conclusion: Depending on the outcome of the current independent Buckingham review (4), all computing departments to achieve Athena SWAN Silver award or equivalent. The Athena SWAN Charter recognises and celebrates good practices in higher education and research institutions towards the advancement of gender equality. (5)



BUILDING A SUBSTANTIAL PIPELINE FROM ARTS AND HUMANITIES

The government’s AI review [1] of 2016 recommended there should be progression pathways from arts and humanities undergraduate degrees into postgraduate AI conversion courses. Our conclusion combines that idea with the work being done by the Q-Step pilot programme [6] which was developed as a strategic response to the shortage of quantitatively-skilled social science graduates.

Conclusion: Ensure there are a broad range of arts and humanities undergraduate degree courses that include quantitative methods as a significant ‘with’ component offered across the UK (e.g. such as BA in Social Sciences with Quantitative Methods), and which are partnered with MSc AI conversion courses tailored to arts and humanities graduates.



CONSULTATION FINDINGS BEHIND OUR CONCLUSIONS

We've summarised the findings from our consultations, roundtables and surveys, that led to those findings below.

Employer demands and needs

Our findings: Employers highlighted the need for people who can:

- › ensure AI systems meet appropriate ethical standards
- › are highly skilled at transferring a deep scientific knowledge of AI into business contexts
- › engineer AI systems that meet business needs
- › manage the adoption of AI and maximise its value across strategic business units

Building on the employer consultations, our full report synthesises a high-level set of professional skills split across science skills, data engineering skills, product development skills, business skills and ethical competencies, which have been shared with a wide range of employers for validation.

University interest, capacity and capability

Our findings:

- › There is extensive capacity throughout the UK to provide high quality Machine Learning and AI MSc courses.
- › There is a growing sense of a shared Machine Learning body of knowledge across universities that is highly relevant to the needs of employers.
- › **Risk:** There aren't enough MSc programmes that develop professional skills through extensive work-related experience, but there are MSc courses which are exemplars of how this can be achieved.





The students we surveyed said that certification of both their competency and capability is their most important professional development need.

Our finding: AI MSc courses should ensure students are able to evidence and articulate how their stated professional development priorities have been achieved on successful completion of the programme.

Conclusion: For AI MSc programmes to deliver the best student outcomes, fully support the UK Industrial Strategy and provide value for money, the issues around diversity and inclusivity must be dealt with. There is a growing body of evidence-based solutions that could help with this issue: we recommend that they are implemented as a matter of urgency.

Ethical behaviours

Given the potential impact of AI on so much of the modern world, it is essential that all AI practitioners have the competencies necessary to ethically design, ethically develop, ethically deploy, ethically manage and ethically maintain AI products and services.

Our finding: It is essential that AI MSc graduates should be able to evidence they have the ethical competencies necessary to significantly contribute towards embedding ethical principles throughout the AI product/service lifecycle.

Independent accreditation of AI MSc courses could be one useful mechanism for encouraging the embedding of an 'ethical by design' approach within curricula, as part of a range of incentives for universities to adopt this approach.

The value of work experience

Our finding: Employers' stated preference is for students to develop AI related professional skills through extensive work experience, assessed against industry recognised standards. Many universities reported that adding lengthy placements, such as for nine months, to an already existing one year MSc course will be challenging.

We also found most large employers would prefer industry-funded AI MSc courses be delivered through level 7 degree apprenticeships paid for through the apprenticeship levy.

Challenges: However, it will be very challenging over the medium term to provide enough MSc degree apprenticeships to achieve the aspiration of an additional 3000 student places. Several universities are beginning to scale up their apprenticeship capacity, and some are willing to introduce level 7 degree apprenticeships that develop AI skills if there is demonstrable demand.

Scholarships

Our finding: Employers support student scholarships as a means of providing greater flexibility for students, employers and universities and it allows for more agile innovation in curricula than the apprenticeship model.



TEACHING INNOVATION

Our finding: Many universities are innovating their teaching practices to develop students' professional skills through a variety of work-related experiences both on and off campus, which could help address the work experience issue and should be widely shared across the HE sector. For example, some universities have developed innovative, employer informed curricula. This combines significant employer engagement on campus with short periods of focused, structured work experience off campus, which is evidenced through professional skills frameworks and builds on the professional development gained through the campus based part of the course.

THERE IS EXTENSIVE CAPACITY THROUGHOUT THE UK TO PROVIDE HIGH QUALITY MACHINE LEARNING AND AI MSc COURSES.

SUMMARY

Sunny day scenario: Taking all the data and opinions into account it is plausible to imagine a long-term future where there is a successful mixed MSc economy delivering the aspiration of 3000 AI MSc graduates a year. This would be through a mix of degree apprenticeships, degrees with year-long placements and degrees that embed employer engagement throughout the curriculum and have short structured placements to top that up. The third model would probably take most of the load during the initial years, and the other two would gradually ramp up over time. This could be achieved if somewhere in the region of 60 universities were providing such courses with significant cohorts of around 50 on average.

Underpinning this mixed economy would be ethical and professional AI standards that meant employers and students would know whatever pathway was followed, the same outcome would be achieved. There would also have to be a supporting infrastructure to achieve long term substantial and sustainable improvements in diversity and inclusivity.

CONSULTATION STAKEHOLDERS

BCS is grateful for the advice, support and feedback from individuals acting in a personal capacity from the following organisations:

- Practitioners working for Amplify, ARM, BAE Systems, BT Technology, Cambridge Consultants, Cisco, DeepMind, Deloitte, HSBC, IBM, Infosys, Lloyds Banking Group, McKinsey Quantum Black, Microsoft, Nvidia and Ocado
- The more than 50 university computing departments that responded to consultations through UK Clinical Research Collaboration (UKCRC) and the Council of Professors and Heads of Computing (CPHC), as well as the various roundtables and workshops that informed this report
- Officials from the Department for Digital, Culture, Media & Sport, the Office for AI, Department for Education, the Office for Students, and the Department for Business, Energy and Industrial Strategy
- The Institute of Coding, the Royal Academy of Engineering, Technology Catapults, TechUK, the Data Skills Taskforce, and the Alan Turing Institute
- All the BCS students, professional members, chartered IT Professionals and Fellows who have provided insight and advice during the preparation of this work

THE GOVERNMENT RECOGNISES THE DEMAND FOR AT LEAST 3000 AI MSc GRADUATES EVERY YEAR.



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