# An Analysis of Introductory University Programming Courses in the UK


## ABSTRACT

This paper reports the results of a survey of over 70 introductory programming courses delivered at UK universities as part of their first year computer science (or similar) degree programmes, conducted in the first half of 2016. Results of this survey are compared with a related survey conducted since 2010 (as well as earlier surveys from 2001 and 2003) in Australia and New Zealand. Trends in student numbers, programming paradigm, programming languages and environment/tools used, as well as the reasons for choice of such are reported. Other aspects of first programming courses such as instructor experience, external delivery of courses and resources given to students are also examined.

The results in this first UK survey indicate a trend towards...

...especially in the context of substantial computer science curriculum reform in UK schools, as well as increasingly scrutiny of teaching excellence and graduate employability for UK universities.



## Categories and Subject Descriptors

K.3.2 [**Computers & Education**]: Computer and Information Science Education—*Computer Science Education*; K.4.1 [**Computers And Society**]: Public Policy Issues

## Keywords

Introductory Programming, Programming Languages, Programming Environments, Computer Science Education, Higher Education, Tertiary Education, UK


## 1. INTRODUCTION

For many years – and increasingly at all levels of compulsory and post-compulsory education – the choice of programming language to introduce basic programming principles, constructs, syntax and semantics has been regularly revisited. Even in the context of what are perceived to be the most difficult introductory topics in computer science degrees, numerous key themes across programming appear [4].

So what is a good first programming language? The issues surrounding choosing a first language [7, **?**] – and a search of the ACM Digital Library identified a number of papers of the form "*X as a first programming language*", going as far back as the 1980s – as well as the potential impact on students' grades and attainment [**?**].

Decades of research on the teaching of introductory programming has had limited effect on classroom practice [11]; although relevant research exists across several disciplines including education and cognitive science, disciplinary differences have made this material inaccessible to many computing educators. Furthermore, computer science instructors have not had access to comprehensive surveys of research in this area [10, 11].

However, in Australia and New Zealand there has been longitudinal data collections [12, 9, 8] surveying the teaching of introductory programming courses in higher education. However, such surveys have not been conducted elsewhere on this scale, and this paper reports the findings from running the first such similar survey in the UK.

We remind the reader that the UK consists of four nations historically ruled by one parliament, with an overall population of 64.5 million: England (population: 54.3 million), Scotland (5.3 million), Wales (3.1 million) and Northern Ireland (1.8 million) [**?**]. In 1997, Scotland and Wales held referenda which determined in both cases the desire for self-government (along with Northern Ireland and the 1998 Good Friday Agreement), creating assemblies to which a variety of powers – in particular, education – were devolved from the UK Parliament. In the context of international focus on curriculum and qualification reform to support computer science education and digital skills in schools, the four education systems of the UK have proposed and implemented a variety of changes [**?**, 2], particular in England, with a new compulsory computing curriculum for ages 5-16 from September 2014.

For universities across the UK offering computer science degrees, this curriculum reform in schools has had uncertain (and emerging) impact on their undergraduate programmes, with the diversity of educational background of applicants likely to be increasing before it narrows: it is certainly possible for prospective students to have anywhere from zero to four or five years experience (and potentially two school qualifications) in computer science with some knowledge of programming.

Over the past three years, there has been increased


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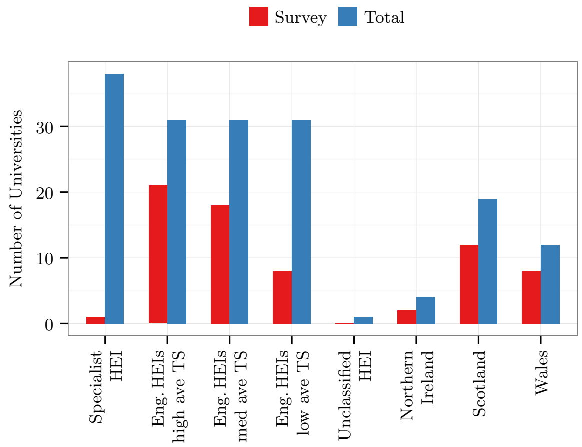



**Figure 1: The number of responding universities per Nation/ Tariff Group.**

**Table 1: The number of programming languages used in first programming courses.**

| Languages | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Courses | 59 | 17 | 3 | 1 |

scrutiny of the quality of teaching in UK universities, partly linked to the current levels – and potential future increases – of tuition fees (generally paid by the student through government-supported loans), as well as the perceived value of professional body accreditation and graduate employability, especially for STEM disciplines. In February 2015, the UK Department of Business, Innovation & Skills initiated independent reviews of STEM degree accreditation and graduate employability[1], with a specific review – the Shadbolt review [**?**] – focusing on computer science degree accreditation (in this case, with BCS, The Chartered Institute for IT) and graduate employability, reporting back in May 2016. Alongside a number of recommendations to address the relatively high unemployment rates of computer sciences graduates, particular on quality of data, course types, gender and demographics, the Shadbolt review split generalist universities in England into three bands, based on their average (across all subjects) entrance tariff (qualifications of entrants); we have followed that banding during our analysis the English results, so our data should allow comparisons.

In this emerging environment of policy, curricula, pedagogy and the evolving demands of high-quality learning & teaching for computer science degree programmes, we present the findings from the first national scale survey of introductory programming languages at UK universities. Through this survey, we identify and analyse trends in student numbers, programming paradigm, programming languages and environment/tools used, as well as the reasons for choice of such are reported. Other aspects of first programming courses such as instructor experience, and resources given to students are also examined, along with comparisons to the Australasian surveys.

[1]https://www.gov.uk/government/collections/graduate-employment-and-accreditation-in-stem-independent-reviews

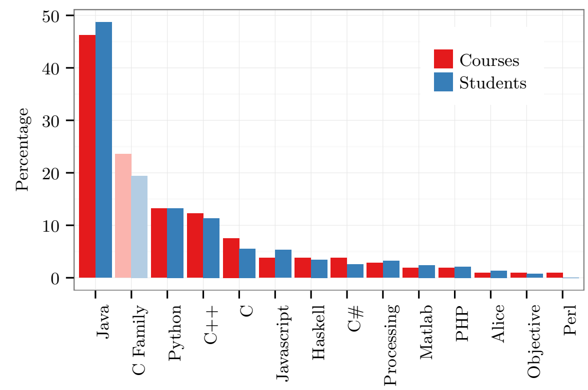



**Figure 2: Language popularity by percentage of courses and students (excl. OU).**

## 2. METHODOLOGY

### 2.1 Recruitment of Participants

To recruit participants for the survey, a general invitation email was sent to the Council of Professors and Heads of Computing (CPHC) mailing list. CPHC have members from over 100 UK universities, and are the representational body for this group in the UK[2].The invitation asked for the survey to be passed on to the most appropriate person to complete it; Director of Studies, Chair of Teaching Committee or the best fit for the individual institution. A couple of reminder circular emails were also issued.

The survey was hosted online and was open from mid-May until the end of June 2016, at which point it was closed and the results were downloaded and analysed. Due to the recruitment method, there were duplicate responses from some departments, and these were reconciled by direct enquiry.

### 2.2 Questions

The questions used in the survey were generously provided by the authors of [8], so as to allow direct comparison between the results of this survey and that of the Australian/New Zealand 2014 survey. Where possible, questions were left unchanged, although a small minority were edited to reflect the UK target audience.

As defined in [8], text in the survey made clear that the terminology "course" was used for "the basic unit of study that is completed by students towards a degree, usually studied over a period pf a semester or session, in conjunction with other units of study".

The first section of the survey asked about the programming language(s) in use, the reasons for their choice, and the perceived difficulty and usefulness of the programming language(s). Following this were questions regarding the use of environments or development tools; which ones were used, the reasons for their choice and the perceived difficulty. General questions about paradigm, instructor experience and external delivery were asked, along with questions regarding students receiving unauthorised assistance, and the resources provided to students. Finally, participants were asked to identify their top three main aims when teaching introductory programming, and were also allowed to provide further comments.

[2]https://cphc.ac.uk/who-we-are/

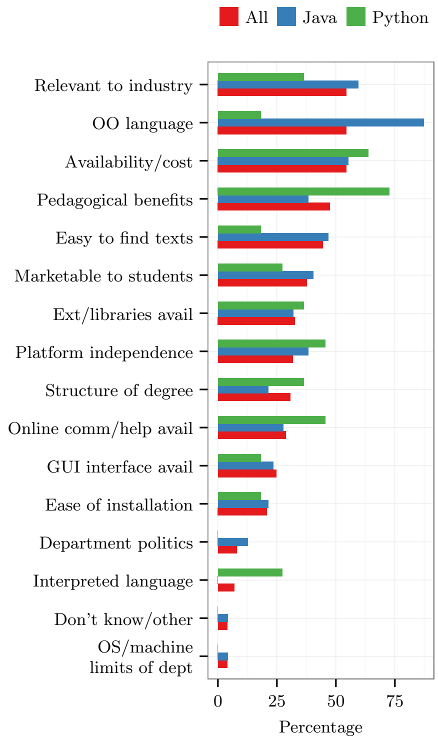



**Figure 3: Reasons given for choosing a programming language by percentage for: all languages; Java; and Python.**

In [8], participants were asked to rank the importance of the given reasons for choosing a programming language, environment or tool. Due to technical limitations in online survey tool used, it was not possible to do so in this survey, so our Figure 3 just reports counts.

Most questions were not mandatory; the exceptions were "what programming language(s) are in use?" and a small number of feeder questions to allow the survey to function correctly.

# 3. RESULTS AND DISCUSSION

## 3.1 Universities and Courses

Upon completion of the survey, 155 instructors had, at least, started the survey. Sixty-one of these dropped out before answering the mandatory questions, and a further 14 were duplicates. Therefore, the results presented here are drawn from the responses of 80 instructors from at least 70 universities. Some participants did not answer all questions and due to this the response rate varies by question.

Excluding the Open University's 3200 students, the participants in the survey represented 13462 students, with a mean of 173 (but a standard deviation of 88). Looking at Figure 1 we see good response rates, apart from the specialist HEIs (most of whom do not teach computing) and the "low tariff" English ones. Fewer of these teach computing, this factor alone explains the response rate. In Northern Ireland, we had responses from the two universities, but not the university colleges, which are historically teacher-training colleges.

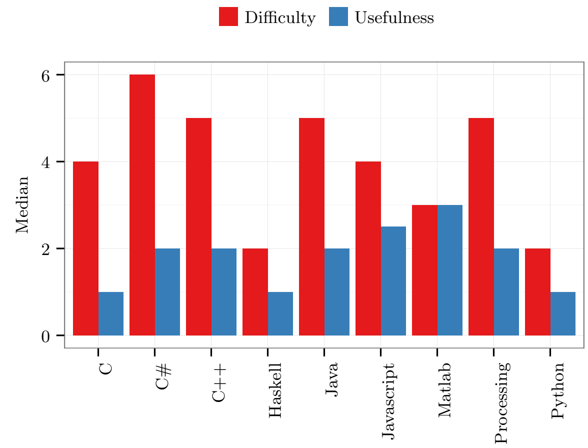



**Figure 4: The median of the perceived difficulty and [pedagogic] usefulness of language, where 1 is 'extremely easy/useful' and 7 is 'extremely difficult/useless'. Answers must have been given by at least two instructors.**

**Table 2: The main paradigm in use in the first programming course.**

| Paradigm | Object-Oriented | Procedural | Functional |
|---|---|---|---|
| Courses | 40 | 27 | 7 |

## 3.2 Languages

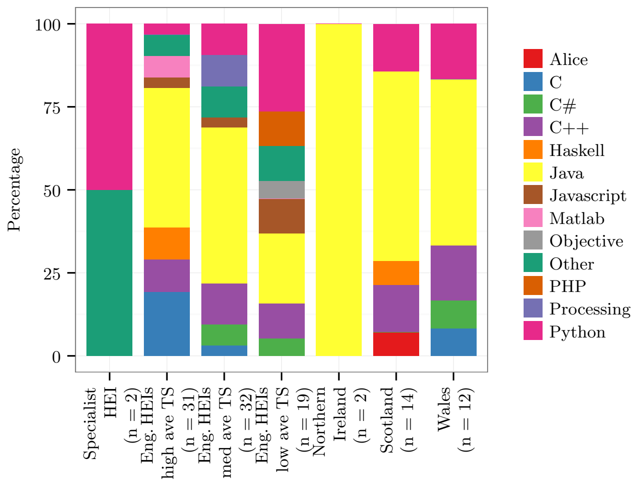
This is the immediate major difference with [8]. Their survey showed a dead heat (27.3% of language instances) between Java and Python, with Python winning (33.7% to 26.9%) when weighted by the number of students on the course. Our findings (Figure 2) show that Java is a clear winner by any metric, being used in over half the courses (61.3%) and just under half of all language instances (46.2%), while the runner-up, Python, is in use in 17.5% of courses and makes up 13.2% of language instances. The C family (C, C++ and C#) together is in use in 31.3% of introductory programming courses, and scores 23.6% of language instances by number of courses and 19.5% by students. Figure 2 shows the effect of student-number weighting *but* we have excluded the Open University from this weighting, as its 3200 students learning Python (and Sense, a variant of Scratch) would have distorted the comparison.

Figure 3 shows some of the reasons for this: Java scores higher on "relevance to industry" and, perhaps somewhat surprisingly, much higher on "Object Oriented language".

Figure 5 breaks down the choice of language by nation and tariff group. It is noticeable that the three English tariff groups differ significantly, with Python outnumbering Java in the low tariff universities, and C being almost exclusively in the high tariff universities.

**Table 3: The number of years the instructor has been involved in teaching introductory programming.**

| Years | <2 | 2 - 5 | 5 - 10 | 10 - 20 | 20 - 30 | >30 |
|---|---|---|---|---|---|---|
| Instructors | 3 | 9 | 9 | 27 | 19 | 7 |



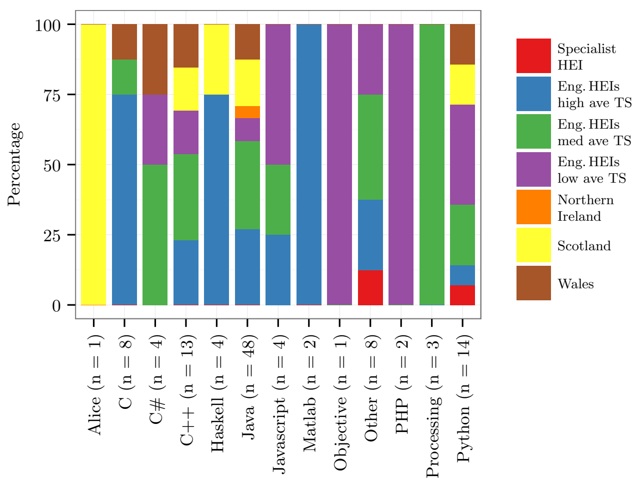




**Figure 5: The breakdown of programming languages by Nation and Tariff Groups.**

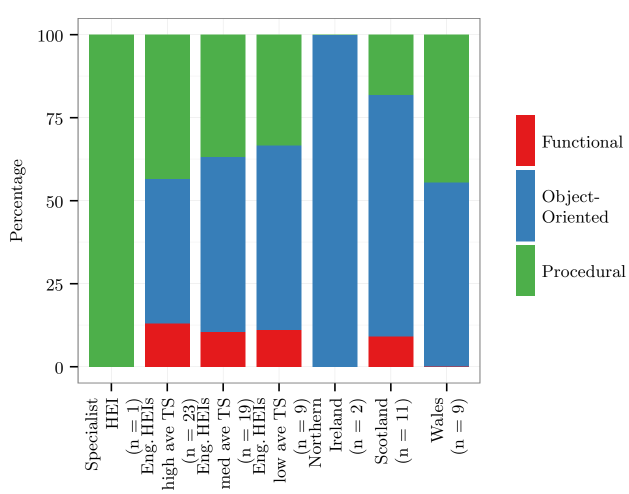



**Figure 6: The breakdown of the main paradigm in use for every Tariff Group.**

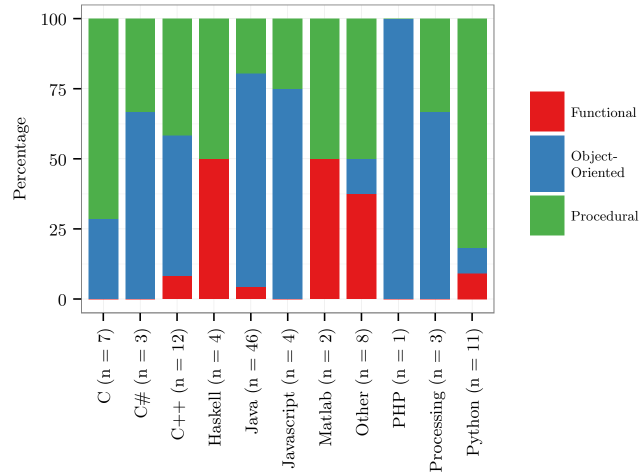



**Figure 7: The breakdown of the main paradigm in use for each programming language.**

**Table 4: The number of tools/environments used in first programming courses.**

| Tools | 1 | 2 | 3 | 4 | 8 |
|---|---|---|---|---|---|
| Courses | 34 | 15 | 6 | 2 | 1 |

## 3.3 Instructor Experience

Participants were asked: "How many years have you been involved in teaching of introductory programming?". The results, shown in Table 3, indicate that of the survey participants, the average was between 10 - 20 years.

## 3.4 IDEs and Tools

Various data about IDEs and tools are collected in Figures 8–11. We note that, while Eclipse is the most popular tool by some way (Figure 8), it is also deemed to be most difficult (Figure 11). This, apparently perverse, practice might be explained by the extent of re-use of Eclipse in other courses (Figure 10).

## 3.5 Other Aspects of the Course

The questionnaire asked about the resources in terms of examples, books etc. provided to students. The results are rather similar to [8, Figure 14] so we do not repeat that here: details are in the full paper.

Conversely, [8] asked about **@Ellen: exact question please** but didn't give the results in their paper. We report our results in Figure 12, as we think they are of general interest.

## 3.6 Aims of an Introductory Programming Course

[8] asked their respondents for the aims of their introductory programming course. They, and we, asked for (up to) three aims. The authors then attempted to classify the free-text answers into the same categorisation as [8] used. While it is trivial to map the written aim "Thinking algorithmically" to [8]'s "Algorithmic thinking" and so on, many were not so clear: for example, we mapped "To learn a specific language" to "syntax/writing basic code". There were also a class of aims, such as "Establish professional software de-

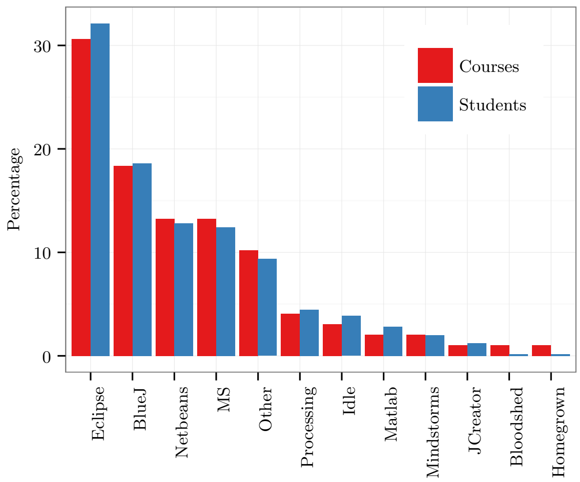



**Figure 8: Tool or environment popularity by percentage of courses and students.**

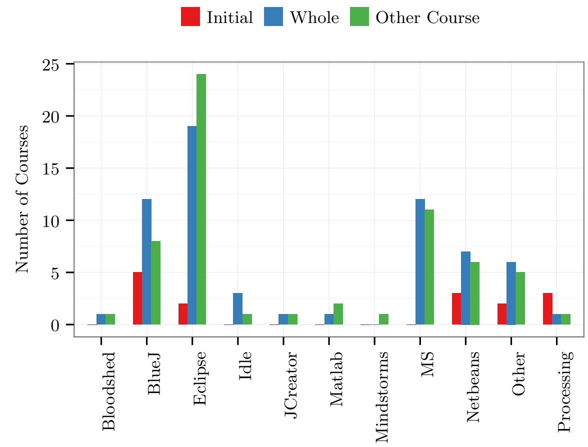



**Figure 10: For each tool or environment, whether it is used: for an initial part of the first programming course; throughout the whole of the first programming course; in any other course in the degree.**

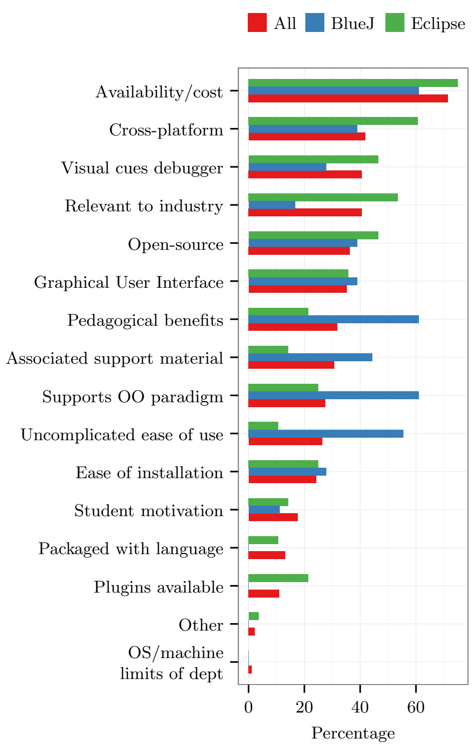



**Figure 9: Reasons given for choosing a tool or environment by percentage for: all tools and environments; BlueJ; and Eclipse.**

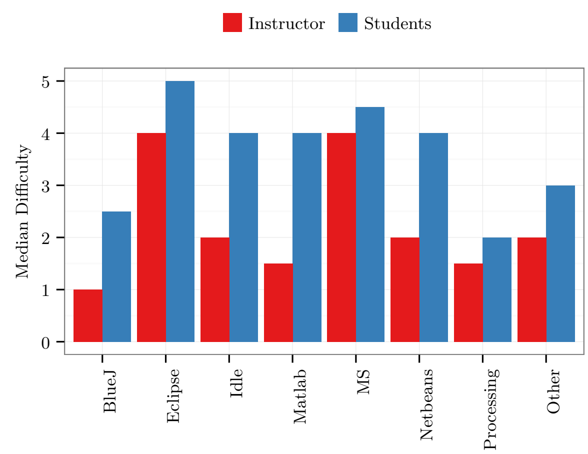



**Figure 11: The median difficulty rating of tool/environment for the instructor and students to use, where 1 is 'extremely easy' and 7 is 'extremely difficult'. Answers must have been given by at least two instructors.**

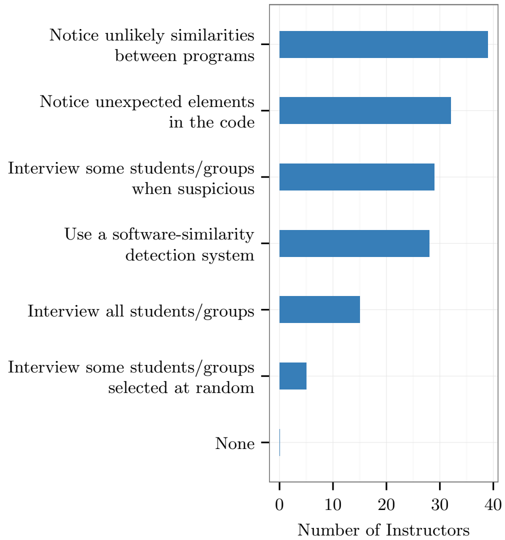



**Figure 12: Steps taken to determine whether students have received unauthorised assistance on assignments.**

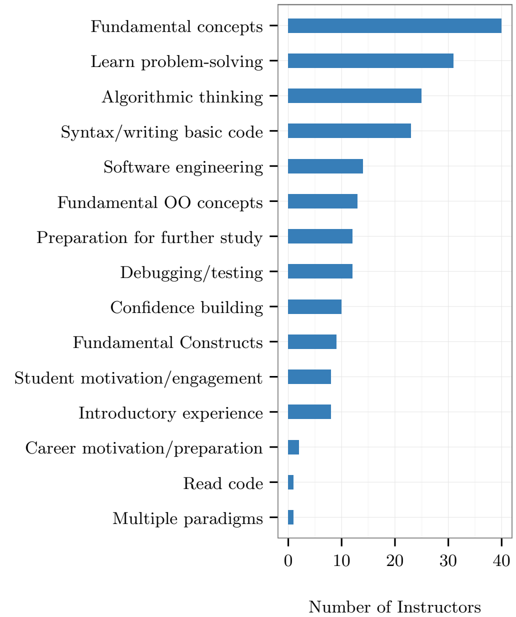



**Figure 13: Aims of the introductory course.**

velopment practices", that seemed very coherent, but didn't map clearly to the [8] aims. These we have categorised as "Software Engineering".

# 4. GENERAL DISCUSSION

## 4.1 The U.K. context

## 4.2 Comparison with Australasia

Here we compare with [8], the latest Australasian survey. We have already commented on the major difference in language choice, which colours many of the other comparisons. n fact, the U.K.'s language choices seem more similar to Australasia's 2010 choices [9] and [8, Table 4] than even Australasia's 2013 choices. It is hard to know which comes first, but we also notice that our difficulty/utility data (Figure 4) is somewhat different from [8, Figures 7,8]

Another difference shows up in the tools/enviroments are: Figure 8 versus [8]'s Figure 11. There, "None" and "Other" were the top two categories, with Idle, at 15%, the most popular named product. In the UK, "Other" is fifth and Idle seventh, with no "None" @Ellen: is that right?.

# 5. ACKNOWLEDGEMENTS

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