What do in-service teachers believe about the aims of science education?

Thomas H. Y. Tam and **Helen Gourlay**

This article reports a small-scale study investigating the views of in-service teachers on the aims of compulsory secondary science education (11–16) in England. Questionnaire and interview data suggest that teachers believe that the ideal science education should be inspirational, exploratory, skill-based and child-centred. This is contrasted with the current curriculum, which is perceived as content-heavy and lacking in skills. Operating under conflicting aims, limited resources and external pressures, teachers resort to finding compromises, enacting their ideals in the classroom under the constraints of an often-prescriptive curriculum.

1

In most secondary schools in England, science is compulsory in the 11–16 age range and the national curriculum underpins most of what is taught in science classrooms. The aims of science education are widely discussed in the literature and in material aimed to educate future science teachers (Harlen, 2018; Mansfield and Reiss, 2020; Garrett and Hetherington, 2024). To what extent do teachers believe in these aims? And what do teachers do if they disagree with the aims of the curriculum and policies under which they operate?

This article reports the findings of a small-scale empirical study conducted as part of the MA Education (Science) programme at the Institute of Education, University College London. Our main research question was: *What do in-service, secondary science teachers believe to be the main aim(s) of science education in schools at key stages 3 and 4 in England?*

To answer this question, we compiled a list of 27 aims from the academic and professional literature, including publications from the Department for Education (DfE) and Ofsted (England's inspectorate). These aims encompassed diverse perspectives, which we categorised broadly into nine categories (Table 1).

Table 1 Categorisation of the 27 aims used in the questionnaire

Category of aims	Emphasis: The aim of science education is …
Activism	to help students take science-informed actions in their community, e.g. a change in consumer choices in response to climate change
Career	to prepare students for the next steps in their education and career, e.g. help them get good grades and gain skills that make them more employable
Criticality	to develop students' critical thinking and problem-solving skills
Culture	to promote students' curiosity and appreciation of the intellectual achievements of science
Democracy	to help students become scientifically informed citizens in a democratic society
Diversity	to reduce inequalities and help students recognise the contributions of minority groups to science
Economy	to supply the economy with future scientists and maintain the country's economic competitiveness
Scientific methods	to develop student's understanding of the natural world and the methods of science
Wellbeing	to provide students with a background understanding of issues in their lives so that they can lead flourishing lives and help others do so

We used an online questionnaire to gauge to what extent in-service teachers agree with these aims. This was followed by interviews where teachers were given the opportunity to express their views more freely. We explored how teachers operate in the classroom when conflict arises between their beliefs and the prescribed or implicit aims of the curriculum, and the factors influencing the formulation of teachers' beliefs. The results allowed us to begin to understand what teachers believe to be the aims of science education, what influences them, and how their beliefs influence their classroom practice. Insights from this study will be valuable for readers responsible for science curriculum development and science teacher education. Our results would also inform school leaders and policymakers concerned with recruitment and retention, and suggest how the wellbeing and job satisfaction of science teachers may be enhanced.

Methodology

This study followed BERA's *Ethical Guidelines for Educational Research* (British Educational Research Association [BERA], 2018) and was approved by UCL Institute of Education Research Ethics Committee. Online questionnaire and interview data were used to triangulate findings. The data were collected in 2023.

Participants

Participants were recruited as volunteers from the researchers' contacts in schools and from verified contacts on social media platforms such as *LinkedIn*. The final group of participants consisted of ten teachers with a range of experiences (from less than three years to more than ten years). Five of the participants worked in either an academy or a free school, and the

2 remaining five worked in an independent school. Four participants (from two schools – one state, one independent) were subsequently interviewed. They were given the pseudonyms Amy, Danni, Ed and Harriet. All participants were in-service secondary science teachers in England.

Data collection and analysis

Questionnaire

An online questionnaire was used to gauge teachers' levels of agreement with the aims. The mean level of agreement for each aim was summarised by calculating the mean Likert score for each aim (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5).

Interviews

The interviews ranged from approximately 15 to 35 minutes and were conducted online. They were video-recorded and transcribed with the interviewees' consent. Themes from the participants' responses were identified via a coding process that identified recurring ideas. It became clear that teachers associated certain themes with the current state of science education (the status quo) and others to their ideals (Figure 1).

Results and findings

3 ### Questionnaire

The questionnaire investigated the alignment between teachers' views and a set of pre-defined aims from the literature. The questionnaire presented teachers with a selection of 27 aims preceded by the sentence: '*The main aim of science education in schools at key stages 3 and 4 is …*' Table 2 shows the aims with the highest level of agreement among teachers.

Table 2 Aims with the highest and lowest mean Likert scores.

Teachers agree most strongly with …	Teachers agree least strongly with …
CRIT1: to promote critical thinking and enhance students' problem-solving skills (4.6) **SCIM1:** to introduce students to a scientific understanding of the natural world (4.6) **CUL3:** to stimulate students' curiosity, interest and enjoyment of science (4.5) **DEM3:** to equip students with the scientific knowledge required to understand the uses and implications of science, today and for the future (4.5) **DEM1:** to equip students with sufficient scientific knowledge so that they can engage in public discussions and participate meaningfully in the democratic process (4.4)	**ECON3:** to maintain the UK's competitiveness internationally (2.5) **ECON1:** to supply the economy with future scientists (2.8) **ECON2:** to supply the economy with a workforce for science-related jobs (3.1)

Numbers in brackets represent average Likert score (n =1 0; 1 = strongly disagree; 5 = strongly agree). Categories represented by the aims: criticality (CRIT), scientific methods (SCIM), culture (CUL), democracy (DEM), economy (ECON). (A copy of the original data, including the full list of aims and their average Likert scores is available from the authors upon request.)

These results indicate that teachers believe that, first and foremost, science education at key stages 3 and 4 (ages 11–16) should promote critical thinking, enhance students' problem-solving skills and introduce students to a scientific understanding of the natural world. This resonates strongly with aims stated in the national curriculum. While communications among policymakers often emphasise the economic importance of science education, for example, to provide enough skilled workers to support an advanced economy, teachers considered the economy a much lower priority.

In contrast with the questionnaire, the interviews provided opportunities for teachers to define and articulate their own beliefs more openly. This allowed clarification on what teachers believe should be the aims (the ideals) and what they perceive to be the de facto aims under the current system (the status quo).

4

Misalignment of aims

Every teacher interviewed expressed some conflict between their own educational aims and perceived external aims from their current education settings (Figure 1). For example, Danni explicitly distinguished her *'personal aims'*, *'the aims of the school'*, and *'the aims of the government and the country'*. Similarly, Ed sought clarification as he reflected on the aims of science education at key stage 4:

> *I would say at key stage 4, it is trying to give as uniform a grounding in the understanding of the world around them, as far as we can for the younger population. And just to clarify, are we talking about the Department for Education's intention when they define curriculum? I just wanted to check because it's … I feel like it's quite different – the opinions of what science teachers are intending from that and what the policy is intending. (Ed)*

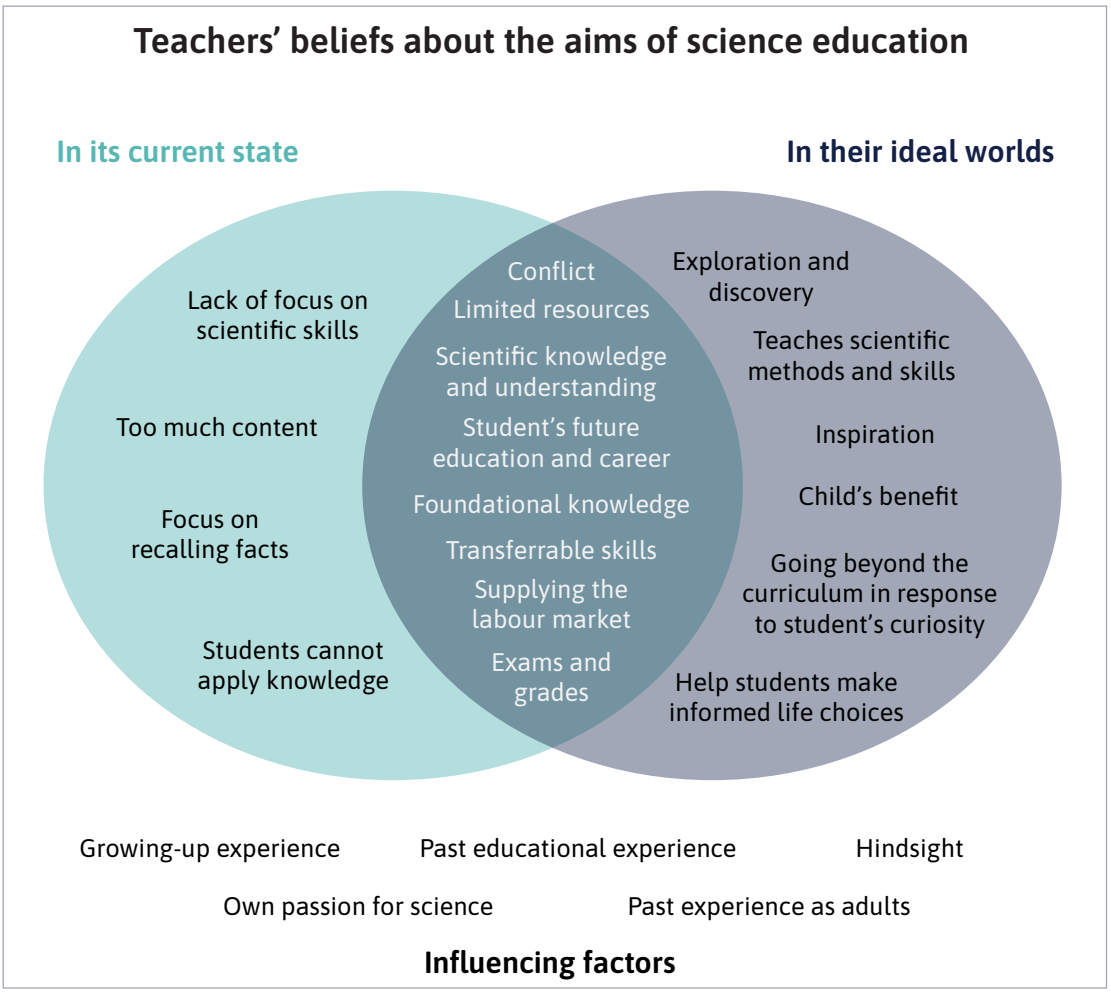
This difference is important, as teachers believe that there are aims embedded in the current system that they disagree with, and there are other aims that they believe should be the aims of science education that have not been implemented. In other words, teachers distinguished what they perceived to be the de facto aims of the current system – what the current system really promotes and values in practice (despite its stated aims) – and the aims that they believe ought to be promoted and valued by an ideal science education. At the intersection between the status quo and the ideal lie what teachers consider to be realistic concerns, such as the need to get good grades in exams, and time constraints, meaning that a compromise must be sought between their ideals and the pressures they work under.

Dissatisfaction with science education at key stages 3 and 4

One of the most prominent themes emerging from teachers' view on the aims of the current system is the lack of emphasis on scientific skills:

> *I think there's a real mismatch in the perception of the aims and what is really happening, because we all know we are meant to be focusing on the why – working scientifically is part of the specification. However, that's not what's really tested in the exams. (Harriet)*

For context, all GCSE science curricula include components that promote what is variously called 'how science works', 'ideas of science', or 'scientific thinking'. These account for 15% of the total marks for a science specification. Harriet suggests that there is a mismatch between the stated aims and what is really happening in assessments. The conflict between an ideal (teaching how science works) and reality (such skills are not important in exams) means that teachers have to abandon what they believe to be important and focus instead on what will give the best results. What is testable becomes what is important in science.



▲ **Figure 1** Qualitative analysis of the interview transcripts. A Venn diagram showing the themes associated with teachers' beliefs about the aims of science education in its current state and in their ideal worlds. Themes that were mentioned in both contexts are presented in the overlapping area. A summary of the influencing factors is also included.

A closely related theme is that teachers consider the current curriculum to be too content-heavy, with negative consequences:

> *I think one problem we have in the curriculum is that because we have so much we have to cover, we almost tamp down on student curiosity and their exploratory nature. (Danni)*

In summary, our analysis suggests that teachers have a negative view on the de facto aims resulting from the implementation of current policy and curriculum.

The ideal science education: inspirational, exploratory, skill-based and child-centred

If the current system is unsatisfactory, what does the ideal science education look like according to the research participants? Two dominant aims for an ideal science education emerged (Figure 1):

- **Exploration** – *to foster curiosity, to encourage discovery and student-led activities.*
- **Inspiration** – *to inspire a sense of love, excitement, enthusiasm, enjoyment, passion, amazement, fascination and a sense of wonder for science.*

These two aims are often linked, sometimes even causally, in teachers' beliefs:

> *My job was to make sure that I expose students – both those that are already exposed and those that may not necessarily get the opportunity – to how amazing science is, give them every story on Earth and try to expose them to as much as possible so that they look forward to discovery. (Amy)*

Similarly, Harriet, talking about how science education should be organised for a student who is likely to pass their GCSE exams, said:

> *What you need to do is, in my opinion, discovery work in year 10 to get the buy-in, and then, year 11, nose-to-the-grindstone exam prep. (Harriet)*

Closely associated with the first two aims are the focus on what may be summarised as scientific methods and skills, which encompass such things as the nature of science (Amy), the ability to do independent research (Danni, Ed), the development of logical, analytical thinking (Ed), deciding whether a source is trustworthy (Harriet), and an appreciation of the limits and evolving nature of scientific knowledge (Harriet):

- **Scientific methods and skills** – *to help students understand scientific methodologies, promote logical and analytical thinking, and help students appreciate the trustworthiness, limitations, and the evolving nature of science.*

The idea of child-centredness unites many of the themes that teachers included in their discussion of an ideal science education, whether it be helping students make informed life choices, enhancing their future career, or adapting teaching to respond to scientific questions most relevant in the students' contexts, even if it means going beyond the prescribed curriculum.

We note that teachers recognise that the current system has positive elements. For example, aims associated with the current system are also found in teachers' ideal world:

- **A strong foundation** – *To provide students with a strong foundation in their scientific knowledge and understanding.*
- **Good grades** – *To ensure that students can get good grades to unlock their future education and career.*

However, as far as teachers' ideal science education is concerned, such aims are considered necessary but not sufficient. As Amy puts it:

> *They can get good grades. But are they as interested in science as they should be or as they could be?*

Similarly, when discussing whether current science education is fit for purpose, Harriet commented:

> *If it's to collect grades to unlock the next level of your education, it is brilliant. It depends on what your aspirations are. If you want to go and be a medical doctor, you're going to need your GCSEs, in which case arguably my job is to get you the best ways possible to get you to your career. If, however, it is the love of science, then no.*

These quotes suggest that teachers are not satisfied when students are just gaining knowledge and remembering facts, even if they are getting good grades. This is supported by the prevalent negative comments associated with teachers' perception of the current science education system, such as too much content, too focused on recalling facts, and the neglect of application and scientific skills.

5

Teachers endeavour to realise their ideal aims within the confines of the current system

The teachers are aware of the conflict between their personal ideals and their current settings. The lack of resources, such as time and members of staff, are most often blamed for

this misalignment. As a result, science teachers are under pressure to either act against their beliefs, defy some external requirements, or find a compromise:

> *I know what I'm meant to do. And I do it. But I can't help injecting what I think I should do. So I definitely follow the rules, but not necessarily the spirit of the rules.* (Harriet)

This theme of enacting the ideal within the constraints of the current system is present in all the teachers interviewed. Amy and Harriet would attempt to make lessons more exciting and engaging; Danni would ensure that students enjoy the lessons and gain valuable life skills; Ed would try to build in more analytical and research tasks in his lessons. In short, these findings suggest that teachers do not simply 'deliver' a curriculum, but adapt it in such a way that will allow them to realise what they believe to be the true aims of science education.

Teachers' beliefs influenced by personal experiences

Why do the participants ascribe such high value to inspiration and exploration? Why do teachers think that having good grades in science is insufficient? An analysis of the themes associated with influential factors reported by teachers suggests that teachers' beliefs about the aims of science education are heavily influenced by deep personal and educational convictions and experiences. For some, the emphasis on interest and a love for science seems to have been passed on from the previous generation:

> *I used to go to the [salt] mines with my dad and he would talk me through the whole electrolysis stages, and I still remember that, and I must have been about 9 or 10, and then we used to do things like go to the Coca-Cola factory and actually watch like glass production, like steam distillation, and all the things that I do now are heavily influenced by the experiences that I myself had.* (Amy)

> *I love science and I got taught by two amazing scientists looking back, who seemed a bit risky. You didn't quite know where it was going and there were lots of explosions and excitement and we had to evacuate the lab. It was like, what's that! You know? And it was really exciting.* (Harriet)

It is not surprising, then, that Amy and Harriet emphasise exploration and inspiration (although all the teachers express similar aims). Similarly, Ed's strong emphasis on teaching analytical skills appears to stem from his own difficult experience transitioning from school to higher education:

> *Throughout my undergraduate and postgraduate career at university, you have a very steep learning curve into a different kind of education, different kind of learning. I think most of my views come from trying to I guess, um – not sure about the word – 'de-steepen' the learning.* (Ed)

In the same vein, childhood experience (and subsequent disillusionment) has a strong influence on Danni:

> *I've grown up in a generation where I was told: Go to school. Get good grades. Go to university and you'll get a good job. You'll get a good pay. You'll get a nice house and your life will be sorted. And I think a lot of people our age were kind of sold that dream when we were growing up. … I've seen that not work for so many people, my ideals have then shifted for, well, if we're going to put all of this work in and we're going to go to university, we're going to go to school. It should be because we enjoy it, we love what we do, we're enjoying the things we learn about and ultimately, we're getting the tools we need in life to succeed.* (Danni)

These findings suggest what a teacher believes to be an ideal science education is heavily influenced by their own personal experiences.

Discussion

There is a broad agreement between the questionnaire and interview findings. Scientific knowledge and skills, curiosity and enjoyment, and critical thinking are some of the main themes that emerged from both phases of this study. Teachers' beliefs about ideal aims align most strongly with what Harlen (2018: 3) called the 'affective dimension' – the aim to '*develop and sustain learners' curiosity about the world, enjoyment of scientific activity*'. Despite the small sample size and the risk of volunteer bias, our findings are remarkably consistent with the broader picture. For example, Oxford University Press (2021) surveyed 398 teachers from 22 countries and found that teachers view inspiration and interest, knowledge and skills for experimentation, and personal outcomes as the most important features of science education. From the academic literature, the focus on analytical thought and the methods of science strongly resonates with the views of Rudolph (2023), who stresses the importance of educating the public about the nature and processes of science. The child-centred aspects of teachers' ideal aims, especially the aim to help students make informed decisions, most strongly echo Reiss and White (2014).

Interestingly, the democratic dimension of the aims of science education (e.g. items DEM3, DEM1) that teachers strongly agreed with in the questionnaire did not feature strongly in the interviews. This may be explained by the child-centred nature of teachers' beliefs, which would foreground individual flourishing (Reiss and White, 2014) rather than the long-term, collective improvement of society (Osborne, 2010; Rudolph, 2023). The two phases are also consistent in suggesting that other aims, including aims associated with activism or diversity, are not foregrounded in teachers' beliefs.

One interesting feature is that the questionnaire did not capture the highly negative view of aims associated with instilling 'cold facts'. This may be explained by two factors. Firstly, knowledge is seen as a necessary (but not sufficient) component in teachers' ideal science education. Given the limited scope for nuance in the questionnaire, teachers would have viewed scientific knowledge in a more positive light. Secondly, none of the 'knowledge' items in the questionnaire implied that it was excessive. Combined, these data suggest that teachers view the instilling of knowledge per se positively, but react negatively when this becomes excessive and threatens to become the dominant aim, to the detriment of other worthwhile aims.

6

Conclusions and implications

Our findings suggest that in-service teachers believe that science education should primarily aim to promote students' love for science, to help them explore the natural world with the necessary knowledge and skills, and to enable them to succeed in their personal lives. These most strongly resonate with views in the literature that emphasise the enjoyment of science, the importance of discovery work, and the student's own wellbeing. Aims associated with activism, diversity, equity and the economy did not appear to be teachers' priority among the aims of science education at this stage. We hope that this small pilot study will contribute towards the empirical dimension of the ongoing debate (Mansfield and Reiss, 2020) about the aims of science education, and prompt further research.

From a policy point of view, the misalignment between the teachers' personal aims and the aims perceived to be imposed on them may be a cause of concern. Since teachers are responsible for implementing the science curriculum, policies are only as effective as how teachers choose to enact them in the classroom. Working under conflicting

aims is also likely to decrease morale and job satisfaction and has implications for recruitment and retention. Finding the balance between competing aims will be a major challenge for those designing a science curriculum. For the teachers in this study, developing students' knowledge and understanding and supporting them to achieve good exam results are important, but this should not be to the exclusion of developing skills (which are also needed to support the economy), or enjoyment, which arguably would also encourage students to take up science-related employment or study beyond the age of 16. While a science curriculum can contribute to a plethora of aims, policymakers must grapple with how its design reflects the priorities of different stakeholders.

Teachers are strongly influenced by their personal childhood and educational experiences, and this has implications for teacher education. For example, their passion for science, and the desire to pass it on, appears to be a driving factor in what they believe should be the aims of an ideal science education. Relating teachers' personal experiences to philosophical reflections on the aims of science education may be what teacher educators need to grapple with. Furthermore, our findings also highlight the important role that beliefs play in teacher practice and imply that teacher education should not be limited to techniques and practices but needs to include reflections on beliefs. It would be helpful for teacher education courses to enable science teachers to explore and clarify their beliefs about the aims of science education in relation to ideas in the literature. This can perhaps be achieved by supporting them to discuss the conflicts between their own aims, those of their schools and those of policymakers. This would help them reconcile with the differences, and prepare them for the misalignment, or even disappointment, that is likely to challenge them in their future workplace.

7

REFERENCES

British Educational Research Association (2018) *Ethical Guidelines for Educational Research*. 4th edn. London: BERA. www.bera.ac.uk/publication/ethical-guidelines-for-educational-research-2018

Garrett, C. and Hetherington, L. (2024) Becoming a science teacher. In *Learning to Teach Science in the Secondary School, 5th edn.*, ed. Hetherington, L, Graham, L. and Moore, D. Ch. 1. London: Routledge.

Harlen, W. (2018) Aims and approaches of good science education. In *ASE Guide to Secondary Science Education*, 4th edn., ed. Banner, I. and Hillier, J. Ch. 1. London: Association for Science Education.

Mansfield, J. and Reiss, M. J. (2020) The place of values in the aims of school science education. In *Values in Science Education*, ed. Corrigan, D., Buntting, C., Fitzgerald, A. and Jones, A. pp. 191–209. Switzerland: Springer Cham. https://doi.org/10.1007/978-3-030-42172-4

Osborne, J. (2010) Science for citizenship. In *Good Practice in Science Teaching: What Research Has to Say*, 2nd edn., ed. Osborne, J. and ~~Dillion~~, J. Ch. 3. Maidenhead, Berks: Open University Press.

Oxford University Press (2021) *The Evolution of Science Education*. Oxford University Press. www.oup.com.au/__data/assets/pdf_file/0028/186832/The-evolution-of-science-education-Oxford-University-Press.pdf

Reiss, M. J. and White, J. (2014) An aims-based curriculum illustrated by the teaching of science in schools. *The Curriculum Journal*, **25**(1), 76–89.

Rudolph, J. L. (2023) *Why We Teach Science: and Why We Should*. Oxford University Press.

8 **Thomas H. Y. Tam**
~~*is an*~~ *Assistant Headteacher.*
thomtam@protonmail.com
Helen Gourlay
~~*is an*~~ *Honorary Lecturer at IOE, University College London's Faculty of Education and Society, and is currently working as a physics supply teacher in Norfolk .*
h.gourlay@ucl.ac.uk