INCREASING THE QUANTITY AND QUALITY OF SCIENCE TEACHERS IN SCHOOLS: EIGHT EVIDENCE-BASED PRINCIPLES

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England currently has a severe shortage of teachers, particularly in science. With the secondary-age pupil population forecast to grow by 19% in the decade to 2026, and an increase in pupils entering three single science GCSEs, the shortage is set to worsen.

Policymakers are experimenting with marketing campaigns to attract new science teachers and student loan subsidies to improve retention. Despite this, the number of physics and chemistry trainees has declined each year, for the last three years. Most senior leaders and Heads of Science cannot afford to wait for policymakers to solve this problem.

This paper sets out eight principles to inform schools and help science departments increase their teaching capacity, based on a thorough review of existing research. These eight principles cover a range of areas including, teacher deployment, development, pay and management. Implementation is briefly discussed and references to the underpinning research are provided.

1. DEPLOYMENT: INCREASE SPECIALISATION

Teaching multiple subjects increases a teacher's workload because they must master a wider range of content. It also means that they are teaching at least one subject outside of their degree specialism, which requires additional preparation. These additional demands have been shown to increase the chances that a teacher will leave their school (Donaldson & Johnson, 2010; Olmos, 2010; Sims, 2018).

Teachers improve as they accumulate experience in a specific area and specialisation enables them to do this faster. Research shows that this makes teachers more effective, improving pupil attainment (Cook & Mansfield, 2016).

IMPLEMENTATION

Many schools have science teachers working across biology, chemistry and physics. Decision makers within a school should consider increasing specialisation of science teachers by allotting a higher proportion of their lessons in one science, preferably the one in which they have a degree. Some scientists prefer teaching across all three subjects, and this should of course be taken into consideration. For many teachers however, particularly those in the early-career stage, this is unlikely to be ideal.

Achieving specialisation will be harder in science departments that already have shortages, particularly where they currently do not employ any physicists. In this case, offering a mostly-physics timetable could help recruit physics specialists.

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2. DEPLOYMENT: PROVIDE STABLE TEACHING ASSIGNMENTS

As well as specialising in particular subjects, teachers can focus on teaching specific key stages or types of pupils. This is also likely to reduce workload because teachers are more likely to reteach lessons. Indeed, research has shown that teachers who specialise in specific year groups are more likely to remain in their school (Ost & Schiman, 2015).

Specialisation by year group also allows teachers to gain experience teaching specific content more quickly. This helps teachers become more effective (Atteberry, Loeb, & Wyckoff, 2017; Blazar, 2015; Ost, 2014; Wedenoja, 2018).

IMPLEMENTATION

Heads of Science should consider increasing the stability with which teachers are assigned to specific year groups. This may be particularly valuable in science departments that do not have enough staff to specialise across the three sciences.

Assignment to specific key-stages is particularly important for early-career teachers, who are still gaining fluency in planning (Ost & Schiman, 2015). Where staffing pressures make it necessary to add new year groups to a teacher's timetable, departments should provide additional support such as materials and mentoring.

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3. DEVELOPMENT: GIVE NEW SCIENCE TEACHERS ACCESS TO YOUR BEST SCIENCE TEACHERS

Teachers can learn and improve through watching, talking to, and selectively borrowing from other, more skilled teachers. Indeed, around a fifth of the skills of any one teacher has can be explained by the quality of teachers they have worked with in the past (Jackson & Bruegmann, 2009; Sun, Loeb, & Grissom, 2017). The more a teacher seeks advice from a colleague, and the more effective that particular colleague is at their job, the more the teacher will learn (Penuel, Sun, Frank, & Gallagher, 2012; Sun et al., 2017).

IMPLEMENTATION

Early-career teachers learn the most from their colleagues (Sun et al., 2017) but they often do not know who to approach and lack the time to find out. School leaders play a critical role in establishing the connections and norms that enable expertise to move between classrooms (Supovitz, Sirinides, & May, 2010). Heads of Science should systematically identify the development needs of early-career teachers and provide time for them to work with other, more experienced science teachers who have strengths in the same areas (Papay, Taylor, Tyler, & Laski, 2016).

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4. DEVELOPMENT: PROVIDE SCIENCE-SPECIFIC PROFESSIONAL DEVELOPMENT

Professional development that increases science teachers' subject knowledge, as well as their pedagogical skills, has been shown to improve retention (Allen & Sims, 2017). More specifically, National STEM Learning Network's science-specific professional development courses, have been shown to increase science teacher retention. This improvement in retention is most likely due to the increased efficacy and job satisfaction among participating science teachers (Wolstenholme, Coldwell, & Stevens, 2012).

IMPLEMENTATION

STEM Learning operates the National STEM Learning Network (NSLN). NSLN offers regional professional development activities, as well as residential multi-day courses at the national centre in York. These courses cover the full range of the science curriculum and bursaries are available, subsidised by public and charitable funds. You can find more information on their website **here**. The Institute of Physics, Royal Society of Chemistry and Royal Society of Biology also run science-specific professional development for teachers.

If you have early-career science teachers who need to teach outside of their degree subject, due to staffing shortages, consider topping up their subject knowledge in these areas.

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5. DEVELOPMENT: PROVIDE INSTRUCTIONAL COACHING

Instructional coaching involves an expert teacher working with another teacher in an individualised, classroom-based, observation-feedback-practice cycle. Crucially, instructional coaching involves revisiting the same specific skills several times, with focused, bite-sized bits of feedback specifying not just what but *how* the teacher needs to improve during each cycle.

Research shows instructional coaching improves teachers' ability to raise pupil attainment in science (Albornoz et al., 2017; Allen, Hafen, Gregory, Mikami, & Pianta, 2015) and in other subjects (Kraft, Blazar, & Hogan, 2018). Moreover, the same CPD content has a bigger impact on pupil attainment when delivered through coaching, compared to other methods (Cilliers, Fleisch, Prinsloo, Reddy, & Taylor, 2018).

IMPLEMENTATION

Instructional coaching is a very specific form of professional development. If coaching sessions do not involve isolating specific skills, practising them in the classroom, and then reviewing progress in the following coaching session, it cannot be described as instructional coaching.

Providing such coaching requires specific skills. There are a range of well-developed coaching models, one prominent example being the Six Step Model (Bambrick-Santoyo, 2016). Organisations such as the Institute for Teaching, Ambition School Leadership, Chartered College of Teaching and Education Development Trust also provide instructional coaching programmes.

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6. PAY: FLATTEN THE PAY GRADIENT

Younger teachers' decisions to stay at their current school is much more sensitive to their pay than that of more experienced teachers. Indeed, new teachers' are two to three times more sensitive to pay than a teacher with ten years of experience (Hendricks, 2014). Paying early-career science teachers slightly more money has been shown to increase retention in their current school and in the teaching profession overall (Bueno & Sass, 2018; Clotfelter, Glennie, Ladd, & Vigdor, 2008; Feng & Sass, 2018; Sims, 2017).

IMPLEMENTATION

Schools have been able to set teachers' pay levels, within their broad pay band, since 2014. However, schools are currently facing budgetary pressures and few have much additional money available for pay rises. Cost neutral ways of increasing pay for early-career teachers are therefore needed. One option is to flatten pay gradients, giving early-career teachers more pay initially, followed by slower pay rises thereafter. Because teachers' stay/leave decisions are more sensitive to pay earlier in their careers, this should increase retention.

School leaders can use the references provided below to make an evidence-based case for such changes.

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7. PAY: SET SALARIES WITH REGARD TO OUTSIDE EARNINGS POTENTIAL

Science and engineering graduates earn more than arts and humanities graduates (Britton, Dearden, Shephard, & Vignoles, 2016). As a result, graduates with science degrees tend to earn more outside teaching than inside teaching, whereas those with arts and humanities degrees tend to earn more in teaching (Migration Advisory Committee, 2016).

The difference between teacher pay and non-teacher pay is an important determinant of whether people chose to teach (Ondrich, Pas, & Yinger, 2008). Moreover, early-career teachers (Gilpin, 2011) and STEM graduates (Rickman, Wang, & Winters, 2018) are particularly sensitive to this outside pay ratio. It is therefore unsurprising that science teachers leave the profession faster than other teachers (Allen & Sims, 2017). Being mindful of outside earning potential when setting teacher pay is therefore important for improving retention.

IMPLEMENTATION

Varying teacher pay by subject is not without controversy. Not least because this will involve differentiating pay within science departments, as well as between science and other departments. However, differentiation is likely to make a notable difference to STEM teacher shortages (Sims, 2018).

The path of least resistance for school leaders would be to begin by increasing the salaries of early-career STEM teachers who are new to the school. Indeed, some schools are already doing this (IDR, 2017). This will keep the costs of the changes down, while minimising disruption and investing scarce resources where they are likely to make the most difference. It should help with both recruitment and retention.

School leaders can use the references provided below to make an evidence-based case for such changes.

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8. LEADERSHIP: PROVIDE AUTONOMY-SUPPORTIVE LEADERSHIP

An individual is autonomous if they endorse their own actions. It is important to note that this is not the same as being left to your own devices; if you fully endorse what somebody else asks you to do, you are still acting autonomously. Low levels of autonomy are associated with increased risk that teachers leave (Boyd et al., 2011; Skaalvik & Skaalvik, 2017; Weiss, 1999).

School leaders have a strong influence on a teacher's sense of autonomy. Leadership styles characterised by the monitoring of teacher performance, for example the collection of large amounts of performance data, are associated with an increased desire to leave (Eyal & Roth, 2011). By contrast, leadership styles which involve careful consultation to create buy-in for a clear vision, are associated with reduced desire to leave (Eyal & Roth, 2011; Sims, 2018). Research shows that managers can be trained to adopt a more autonomy-supportive leadership style, with staff being more engaged as a result (Hardre & Reeve, 2009).

IMPLEMENTATION

Autonomy supportive leaders aim to inculcate strong norms and a sense of shared mission in their staff, rather than managing by rules or numbers. They do this by developing connections between their teachers, discussing decisions with staff, taking account of views and carefully communicating the rationale for decisions (Stone, Deci & Ryan, 2009).

Acute accountability pressure makes this difficult in some schools. However, science departments in good and outstanding schools looking to improve retention can benefit from investing in this sort of leadership. Emphasising that data and paperwork are kept to a minimum should also help attract experienced teachers.

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