Article

If only I had time: Teachers' perceptions of teaching high-ability science students

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With many countries relying on science and technology for their economic prosperity, science educators are tasked with nurturing curiosity and encouraging high-ability science students to become creative and innovative scientists of the future. This exploratory case study employed semi-structured interviews to investigate how four award-winning science teachers identified and addressed the learning needs of their high-ability science students. The research was underpinned by a constructivist theory of learning.

Findings suggest that these teachers were not aware of mandated policies for Gifted and Talented students. They used English and mathematics standardised tests for identifying high-ability science students, supplemented with their own approaches to identification. Although literature identifies the importance of student-led science inquiry, we found no evidence of the teachers engaging their students in authentic scientific inquiry to enable them to investigate their own questions. These findings are discussed in the light of extant literature.

Keywords: high-ability science students; gifted and talented in science; identification of high-ability science students

Introduction

The late Sir Paul Callaghan, eminent scientist, passionate orator, and proud New Zealander, promoted his vision for his country *where talent wants to live.* Sir Paul's dream was for New Zealand to concentrate on cutting-edge science and technological innovation by attracting our most able students into the field. It would be fair to say that many developed countries are focussing on science and technology for their future. Policy and practice demonstrates that much is being done to achieve this in New Zealand (Timms & Pirls 2015) by aiming to attract outstanding students to sciences. However, it is unclear how this will be achieved in a climate where students are not choosing to study sciences at secondary school (Education Counts 2015; Kearney 2016).

This research focussed on the teaching of high-ability science students by a purposive sample of science teachers. The four New Zealand teachers were each recipients of a university Excellence in Teaching award. They were invited to give their perspective on how they identify, plan and then meet the needs of their most able science students. With New Zealand schools required by the Ministry of Education to report on how they address the needs of high-ability (or, more globally labelled 'gifted and talented') students, it was important for us to determine how this requirement translates to classroom practice and how teachers are supported to meet the needs of these students. Findings are discussed with regard to educational policy requirements for gifted and talented students and existing literature.

In New Zealand, the National Administration Guidelines (NAGs) 'set out statements of desirable principles of conduct or administration for specified personnel or bodies' that sit beneath the legislation governing the country's education system as it affects schools (Ministry of Education 2017, n.p.). In relation to students who may be gifted and talented, NAG 1 (iii)c requires 'school boards, through their principal and staff, to use good quality assessment information to identify students who have special needs (including gifted and talented), and to develop and implement teaching and learning strategies to meet the needs of these students' (Education Review Office; ERO, 2008, p. 1). While this NAG does not prescribe how staff ought to create and use 'good quality' assessment information, or how they should plan to meet these students' needs, there is a plethora of recommendations both nationally and internationally that describe what effective practice could look like (see, for example, Colangelo *et al.* 2010; Taber 2016; Van Tassel-Baska *et al.* 2008).

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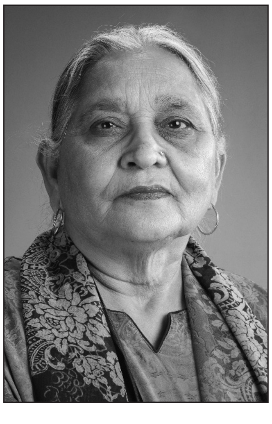

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Given that it is mandated that all schools must assess, identify and make provision for their gifted students, it is reasonable to expect these practices to apply to all schools nationwide. However, ERO (2008) reported that only 42% of those schools reviewed met the needs of high-ability students (i.e. through enrichment[1] or acceleration[2] or a combination of both). Features of the schools that the ERO considered were demonstrating 'good practice' included school leadership, being knowledgeable about effective practice for gifted and talented students, and the schools having responsive and appropriate programmes and well-developed procedures for defining and identifying these students. Interestingly, while the report describes seven cases of effective practice, not all schools included science in their gifted classes. Those that did, cited acceleration provision for the students to enable them to meet criteria for these science programmes. For example, one intermediate school accessed secondary school science for their high-ability students and one secondary school accessed university level science. ERO identified that there were many schools still to make progress in these areas.

A search for international 'requirements' in relation to the education of gifted and talented students revealed wide variation in what is mandated and what is recommended. There is a national mandate in some countries but variation occurs between these nations. In New Zealand, for example, the aforementioned NAG requires schools to identify and report on gifted students. In the United States of America, policy on gifted and talented education is available at state and local levels (Brown & Garland 2015) and in Australia, policy is available at state level (see for example, Australian Capital Territory Government 2017; Government of South Australia 2016). There is variation in policy and practice across Europe, with reports of confusion and inconsistency in Turkey (Mammodov 2015), and collaboration and attempts at cohesion between European countries as they wrestle with issues pertaining to provision and policy for gifted students (Mönks & Pflüger 2005).

Overall, it appears that policy and practice vary between and within countries, but a unifying agenda highlights the importance of differentiated practice to meet the needs of each country's most able citizens.

Defining and identifying high-ability students

Borland (2009) suggests that identifying students for gifted programmes is potentially fraught with challenge as there is no agreement about 'what this construct, giftedness, is, how it reveals itself, or what it is composed of.' (p. 262). He suggests that identification of gifted students must include both predictive validity (does the assessment predict future criteria for inclusion in gifted programmes?) and construct validity (does the assessment measure giftedness?).

International provision for identifying and meeting the needs of high-achieving students is well reported in literature (see for example, Assouline & Lupkowski-Shoplik, 2012; Renzulli & Reis, 2004). New Zealand schools select their own definition and means of identification, with suggested models that include Renzulli's (1978) Three-Ringed Conception of Giftedness and Gagné's (2008, 2009) Differentiated Model of Giftedness and Talent (DMGT). Whereas Renzulli's model focuses on gifted behaviours (above average ability, task commitment, and creativity), Gagné distinguishes between gifts and talents, recognising the developmental process in learning and acknowledging the role of environmental factors in students' education.

Renzulli *et al.* (2009) recognised behavioural characteristics often cited in research that identify students gifted in science. These include curiosity, enthusiasm and interest, and clear articulation of data interpretation. An observational scale comprising these and other characteristics is used to rate students and to measure their interest and engagement with problem solving and understanding of science concepts. Similarly, Taber & Riga (2007) advocate using a range of characteristics to identify high-ability science students, while Kornmann *et al.* (2015) recommend teacher nomination based on their knowledge of the students. Other methods of identifying gifted students include the use of: dynamic assessment (Sternberg & Grigorenko 2002), portfolios (Johnsen & Ryser 1997), and multifaceted tools to ensure identification reflects the diversity of today's classrooms (Borland & Wright 2001). Standardised testing is recommended for inclusion in advanced placement and other elite gifted programmes (Brody 2015).

Regardless of the means of identifying students who are gifted in science, what is arguably more important is ensuring high-ability learners receive an appropriately planned curriculum that enables them to experience 'opportunities for creativity, flexibility, and critical thinking in science … [including] advanced and differentiated services in science.' (Renzulli *et al.* 2009, p. 101).

Provision for high-ability science students

Science education research has identified the importance of gifted science students having a strong understanding of the Nature of Science (NoS) (Gilbert & Newberry 2007; Taber 2016). Gilbert & Newberry (2007, p. 18) state that 'anybody who is in any way gifted in science must be on their way to a grasp of the philosophy of the Nature of Science'. They emphasise the need for these science students to receive high levels of content knowledge. Taber (2016, p. 94) suggests that teaching NoS provides an opportunity to 'engage and challenge those learners who are judged to be gifted in science'.

The role of depth, complexity and authentic enquiry in science education for gifted students is evident in research (Kaplan *et al.* 2016). Van Tassel-Baska *et al.* (2008) and Kaplan *et al.* (2016) not only identified the importance of authentic enquiry, but also cited the need for science teachers of the gifted to consider how lessons are paced, ensuring optimal conditions for teaching and learning while including planning for ability grouping. They reiterated the importance of providing gifted students with a foundation that enables them to become producers of knowledge, gaining internalised scientific skills (observation, experimentation, and measurement) while developing a way of thinking that empowers them to consider the world through the mind of a scientist. Van Tassel-Baska *et al.* (2008, p. 584) identified five key components of science programmes that support gifted students to develop these skills: opportunities to experiment in a laboratory; content-based curriculum pitched

[1] Enrichment 'refers to the provision of learning opportunities that give depth and breadth to the curriculum in line with students' interests, abilities, qualities, and needs' (Ministry of Education 2012, p. 59).

[2] A seminal definition of acceleration describes it as 'progress through an educational program at rates faster or at ages younger than conventional' (Pressey 1949, p. 2).

at a high-level; opportunities to engage with 'real' scientists; focus on inquiry processes; and, science topics that focus on 'technological applications of science in the context of human decision making and social policy'. Unsurprisingly, science-enriched programmes for the gifted impact positively on students' attitudes towards science, with gains in both motivation and confidence in science (Oliver & Venville 2011; Stake & Mares 2005).

Key elements of science programmes for high-ability students are: opportunities to experiment in a laboratory, content-based curriculum pitched at a high level, opportunities to engage with 'real' scientists, a focus on inquiry processes and authentic topics (Han 2017; Kaplan *et al.* 2016; Van Tassel-Baska *et al.* 2008), and the important role of NoS (Gilbert & Newberry 2007; Taber 2016). We consider these in conjunction with national policy and recommended practice alongside the data gathered from the teacher participants in this study.

Life-long learning in science

Nationally and internationally, where students can opt out of studying science they are choosing to do so. A report from the United Kingdom cites parents' and teachers' lack of knowledge about potential careers in science as a reason for students choosing not to continue studying science subjects through secondary school (Kearney 2016). Kearney suggests that encouraging high grades discourages students from studying science as high grades are perceived to be easier to attain in other subjects. A recent Programme for International Student Assessment (PISA) report found that in New Zealand 'There are larger proportions of students with low performance in science … than there were before 2012' (Education Counts 2015). Paradoxically, the report identified that – when compared to other 15-year olds in OECD countries – New Zealand science students were less confident in their own science ability, but had greater levels of enjoyment in learning science, coupled with a higher awareness of the NoS and the utility of science study for later life (Education Counts 2015). While retaining students' interest in science is an issue, so too is the need to ensure that our most able science students continue to study science while receiving a curriculum that is commensurate with their capabilities.

An important component in generating life-long learning in science is the ability to engage students in topics of interest to them (OECD 2008). Engagement encourages students' enjoyment in learning, creates curiosity, and stimulates interest (Mulqueeny *et al.* 2015; Slavit *et al.* 2016). Engagement is important in preventing high-ability students from becoming bored and underachieving (Landis & Reschly 2013; Rubenstein *et al.* 2012).

Methodology

This small-scale exploratory case study was aimed at investigating the perceptions and beliefs of teachers of high-ability science students. Our intention was to gain a deeper understanding of how a group of highly able teachers identified and addressed the needs of their high-ability students. Case studies provide 'thick rich description of the phenomenon under study' (Stake 1995, p. 42) and use an inductive mode of reasoning through which 'generalisations, concepts, or hypotheses emerge from an examination of the data grounded in the context itself' (Merriam 1998, p. 13). We decided that a case study with in-depth interviews with participating teachers was the best approach. The research was informed by the constructivist theory of learning which is underpinned by the idea that knowledge is personally constructed by the learner making connection between new ideas and their prior knowledge. Additionally, a teacher's knowledge and understanding of the needs of high-ability students and providing rich learning experiences for capability-appropriate knowledge construction is essential.

The paper focuses on teachers' views relating to the identification, provision and perceived effectiveness of programmes for high-ability science students in their classes. The research questions were:

1. How do novice teachers in their first three years of teaching identify and make provision for those students of high-ability in science?
2. What evidence do these teachers gather to identify the effectiveness or otherwise of these provisions?
3. What barriers might these teachers identify in meeting the needs of their high-ability science students?

Participants

Participants in this study were four teachers who had each gained an Excellence in Teaching Award, which is their university's acknowledgement of a small group of student teachers who excelled in both the academic and practicum components of their year-long studies in initial teacher education. These student teachers either completed a Graduate Diploma in Teaching or a Master of Teaching and Learning qualification ($n = 250$ to 350). The awards are restricted to ten students ($n = 10$) each year. There were additional student teachers who had gained an Excellence

Table 1. Participant information.

	Years in teaching	Teaching subjects	Current teaching	School type	Relevant background information
Sam	First year	Maths and physics	Maths from Years 10 to 13 (Age 14 to 17 years)	Large (1800 students), state, coeducational	Has worked in government departments. Very capable and has come to teaching in his 50s. Master of Teaching and Learning.
Jane	Third year	Science and chemistry	Year 9, 10, 11 Science, Year 12, 13 Chemistry	Medium (1000 students), state, coeducational	She has a real passion to work with special needs students, very creative, owns a business with her husband and makes science themed jewellery. Graduate Diploma in Teaching (Secondary)
Beth	Third year	Science and physics	Science in Years 7, 8, Physics to Years 12, 13	Small (600 students), private boys	Beth has a PhD in Physics and is a trained clinical psychologist. Graduate Diploma in Teaching (Secondary)
James	First year	Science and physics	Science to Years 9 & 11, Physics to Years 12, 13	Medium (800 students), state, coeducational	James has a degree in Biology and Chemistry Has come into teaching straight after gaining his degree.Graduate Diploma in Teaching (Secondary).

award, but those who were purposefully selected had a background in science, taught science, were willing to participate in the research, and were teaching in local schools accessible to the researchers. All names reported here are pseudonyms and the information provided ensures their anonymity.

Semi-structured interviews of approximately one hour for each teacher took place in the teachers' schools at a time convenient to them. The information sheets and consent forms were sent to the participating teachers beforehand. Table 1 provides descriptive information about the teacher participants in this study.

Each teacher interview was conducted, audio-recorded, and transcribed by the same researcher. Questions were prepared following a review of existing literature, then trialled with a non-participating teacher after which minor changes were made for clarity. The analysis was conducted through reading and re-reading the transcripts and coding statements with similar ideas. A non-participant researcher was asked to code the same interview transcripts and these codes were discussed and agreed upon. The themes that emerged are presented in the results below where we have used a balance of quotations to provide teachers' voices.

Results

The findings presented describe the participant teachers' understanding of ways to identify and provide for high-ability science students, their perceptions of the effectiveness of these provisions, and any perceived barriers to meeting the students' needs.

Awareness of policy for gifted and talented

None of the participating teachers knew about their school's policy for addressing the learning needs of gifted and talented students. Jane said that she had not been given access to such a policy document. She added 'I mean there probably will be a policy somewhere … we have streamed-classes … that would be as far as the policy goes, as far as most teaching staff are aware anyway.' Beth was unsure: 'Yes, I think it is somewhere, I have considered hunting it down. I did the Gifted and Talented course [during her university study] and just follow what I learnt there.' James said that he had not seen such a policy document, while Sam reported that his school had not told him they had a policy but he intended to ask his PRT[3] supervisor about this.

Identification of high-ability students

Participating teachers in this study had not sighted school policy pertaining to identification of gifted and talented students. When asked how they identified these students, all participants said that their schools conducted Progressive Achievement Tests[4] (PATs) for English and mathematics. These tests assess students' mathematics, listening comprehension, punctuation and grammar, reading comprehension, and reading vocabulary. Most secondary schools use these when students enter year 9 (aged 13 years), their first year of secondary schooling. All four teachers had access to the results of these tests and two (Sam and James) said that their school streamed year 9 classes based on these test results.

All four teachers said that they used PATs as a guide; however, Jane did not think they were particularly useful for her students – she had a class of students who all had learning difficulties due to dyslexia, dyscalculia, or dyspraxia. They typically scored lower than other students due to their challenges with reading. Jane said:

> *I think behaviour issues have got in the way of their learning quite a bit and have resulted in lower outcomes and so while they are a challenging class, we also have some high-ability individuals in the class and in general, apart from maybe two or three students, they are probably higher ability than what their PATs show*

Each teacher used additional indicators and, although talking with the students was one way of gauging their ability, all teachers had slightly different ways of identifying their high-ability students. For example, Sam agreed that he considered their test marks along with his own way of deciding. He talked about a girl in his year 9 class:

> *I've kept track of all their results of all their assessments … I had to go on that … there were some students one I put in even though she hasn't done that well because I KNOW [emphasis is original] she's really bright, but it was mainly based on their assessment results and a couple I threw in just because I thought they were pretty talented but they just hadn't really pushed themselves.*

Beth's decisions were based on PATs but she gave priority to 'students who are curious and creative, thoughtful learners, ask questions often…' Importantly, her school encouraged participation in science beyond the classroom, exemplified in the following statement. Beth elaborated that these students have:

> *Consistently high marks in tests, often accelerated in one or more subjects. They are keen to learn, often involved in out-of-class science activities such as Olympics, science fairs, enjoy going to science related talks at Royal Society..*

James identified his high-ability students not based on PAT marks but on how quickly they answer questions and understand conceptual ideas. He found it easier to support the more able learners because, he said, he understands their learning needs. James said he used the following criteria:

- High engagement level and enormous curiosity
- Consistent high grades across all topics
- Fast learners
- Questions that show high level of thinking: visible effort in trying to fit the new knowledge into existing world views or to change the world view to accommodate the new facts.
- Application of newly learnt facts and theory in novel situations.

James added that, 'One of the students I have selected from my year 9 class has a better conceptual understanding of the NoS ideas than my seniors.'

Two of the schools streamed their year groups in years 9 and 10 and put their high-scoring students in an accelerated learning class. As none of the participating teachers were teaching an accelerated learning class, it was unclear whether such classes were given the opportunity to be accelerated to the next level up.

[3] PRT supervisors are in charge of 'Provisionally Registered Teachers' for their first two years of teaching.

[4] PATs are a series of standardised tests developed specifically for use in New Zealand (for further details see http://www.nzcer.org.nz/tests/pats).

Teachers planning lessons to address the learning needs of high-ability students

Sam said that this was his first year in teaching and although he would like to plan lessons to extend his students, he was struggling to find the time to do so. However, he tried to differentiate his teaching so that the more able students had some challenge. For example:

> *….the start-up questions, sometimes they're easy, sometimes they lead into something else. Sometimes they're excellence*[5] *questions because I feel that we didn't do well enough in the previous lesson and need to revise it. I would like to do more.*

Jane added that she makes sure that her high-ability students have an opportunity to learn and excel and gain scholarships in year 13. James was concerned that it is probably his less able students who miss out:

> *I probably pitch my lessons towards the top end and often the less able students do not get the best deal. I am trying my best to differentiate my lessons. Sometimes unconsciously, and too much. As a perfectionist and high achiever myself, I often unconsciously pitch the content to the level that I think I would be happy with, which is higher than the mainstream standard. I bring in anecdotes that demonstrate that theory is interesting and thought-provoking. This often satisfies the top students but confuses the majority. But on the other hand, as a beginner teacher, I am not very good at differentiation. Most of the times I do not have heaps of extension material for the gifted and talented due to time constraints in planning.*

Beth said she was much happier this year; she felt she had time to plan for these students and they responded well. She added, 'Until last year most planning I did was to give them more challenging work sometimes. This year I have definitely managed to plan for them and it is so good to see them blossom.'

Pedagogical approaches to address the needs of high-ability students

Although all teachers were aware of the need to extend their high-ability students in their classes, they gave different examples of their practice; to illustrate:

> *I guess the talented ones, the ones that I know can do things, like they usually jump straight to the more difficult ones and I like spending time with them, getting them to work out how to solve it and maybe just give them a hint…. At other times, when I'm going over something on the board, I will just take it a little bit further and I'll be linking it to other things and other topics that they otherwise wouldn't know. Linking it to next year's maths umm, and saying, I'll just show this, you don't have to know this but I'll just show you it anyway… that works to raise their curiosity. (Sam)*

Jane said she encouraged her students to come up with the kind of interesting questions that would take them beyond the obvious; she thought that helps to develop their thinking: 'I need to ask those questions and have those discussions,' not just to extend them but to keep them curious and interested in 'wanting to learn more.' Having been a scientist, Beth talked about challenging her students through structuring her lessons around a problem and allowing them to work with others:

> *I tend to introduce lessons as problems that need attention, or set up a challenge for the students to work their way through. These students like to work with others of similar ability and interests. So, I have let them choose their own groups to work in and have not had any problems.*

All four teachers gave examples of how they tried to teach the high-ability students in their mainstream classes. For example, James said:

> *When doing experiments, if the more able students finish early, I give them more challenging tasks. For example. after observing and describing the onion epidermis cells, I would ask them why you can hardly see any cells if you put a whole piece of onion under the microscope, or, give them leaf samples and ask them why the onion cells were not green while the leaf cells were. Or ask students to problem solve or design certain things via a circuit, for example, to test knowledge.*

Although all the teachers tried to say they were not doing much for their high-ability students, they each demonstrated an awareness of the learning needs of these students and of providing opportunities to challenge and extend them.

Assessment for qualifications, a main driver for student learning

Sam started his conversation by saying, 'I like assessing them (laughs) but I've only run about four or five other little assessments because I've just been too busy'. Sam appeared to get a lot of pleasure when his students could understand an idea:

> *I like spending time with students, knowing them, being able to read their reactions … from their responses to questions and when you see that 'ah-ha' look in their eye when they get it 'ah', or when you come around and explain it and they suddenly say, 'ohh, I see now'….and get on with it.*

Jane demonstrated her response in terms of how she was trying to get her students to learn so that they succeeded and did not just rote learn the answers to gain a particular grade, emphasising, 'this is the kind of thinking you will need, rather than, this is the kind of answer you need to write':

> *I find it is really important for them to model excellent thinking, whether it's in discussion or starter questions and things and to make sure that I'm going through starter questions or whatever it is we're doing, I'm talking really specifically around, this is how you respond at a merit level. This is the kind of thinking that you need to be showing for excellence.*

Beth negotiated the learning and assessment issues and was clear about the importance of both:

> *Our school likes to have very good results but I like the students to learn and then I help them to prepare for assessment;*

[5] The terms Achieved, Merit, and Excellence in our context align with levels of achievement and, although coined for assessment, they are being used extensively to describe the assessment grades students achieve and have become a way of talking about teaching and learning. Briefly, an Achieved grade indicates that a student can describe things, a Merit grade means they can explain, and gaining an Excellence means they can discuss their responses in a more thoughtful manner. Generally,

- Achieved (A) for a satisfactory performance
- Merit (M) for very good performance
- Excellence (E) for outstanding performance
- Not achieved (N) if students do not meet the criteria of the standard. (http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/how-ncea-works/standards/)

it works especially for more able kinds who really DO want to UNDERSTAND [emphasis original].

James found that his school prioritised learning, which he perceived to be 'great.' He liked the focus on learning but believed that he had some very able students in his class whose needs he tried to address, and he would like to do even more for them. However, most students he taught *struggled* with science and his energy went into supporting them so that they gained at least an Achieved grade. He was spending time with his high-ability students during lunch times and after school to focus on their needs. He enjoyed doing this but it meant he had little time for himself. James laughed and said, 'I guess this is the life of a first-year teacher!' The following year he thought he would have more time. He was satisfied with having some success with raising the achievement level of both the majority of the students in the class and the few who needed extending.

Jane's school was:

Very, very into 'Excellence' grades [laughs] and we're still trying, they [school] still push us to get the kids to Excellence which does mean that you end up rote teaching Excellence skills a bit as opposed to [teaching] thinking in a lot of situations. You have to fight really, really hard to try and encourage the thinking and not just make it content cramming.

Reflecting on her current classes she said, 'They've actually learnt to think a bit more.' Ever concerned about her highly able special needs students, Jane convinced her principal to allow some of her students to sit the chemistry external examination at a higher level, affording them the opportunity for moving into senior chemistry so they were not held back by the class.

Evidence of student learning

When asked how they knew their high-ability students were learning, all teachers said that assessment information and examples of student scores across a range of topics were indicators that students were learning. Sam used:

A whole range of evidence, not just test, their answers, how they explain something to the others, when they come back and ask for clarification. Jim (student) is a very deep thinker. He goes to the philosophy club…. I like talking conceptually; we talk about physics and the universe and stuff like that. What is puzzling is that he failed the last calculus assessment. Yet he seemed to get it in class, understand it in class. One reason can be that he is dyslexic. He has a problem and gets an extra 10 minutes for tests for this reason.

James said he collected his evidence from:

…students' ability to answer the 'tricky' questions; explain complex concepts and phenomena with accuracy and clarity both in class and in assessments; asking thought-provoking questions; and their ability to apply new concepts to novel situations; participating in science related activities after school; self-research on topic of interest; and having the drive to come and want to learn MORE after school.

Beth favoured formative assessment, sometimes running competitive quizzes, using 'Kahoot!' (an online quiz) and tasks for students to do individually and in groups, and she talks with the students while they are working, dropping a question and coming back to them to see where they are at. Jane uses tests, quizzes, formative assessment, and importantly, teaches her dyslexic students how to manage their learning issues and strategies to cope with them.

From the interview data, we analysed how aware the participating teachers were of the policies focussing on the nature of science, aspects of science pedagogical approaches, and programmes within their schools that provided opportunities for acceleration and enrichment of students (*see* Table 2). The sparseness in this table reflects teachers' views.

Table 2. Awareness of teachers on policy, curriculum, and science engagement to support high-ability students.

Teacher	Sam	Jane	James	Beth
National Admin. Guidelines				
Nature of Science			✔	
Laboratory				
Authentic inquiry				
Inquiry			✔	✔
Acceleration	✔			✔
Enrichment				✔

Perceived barriers and teacher concerns

The most common response to identifying perceived barriers to meeting the needs of high-ability science students was 'Time, that's it. I think I could but I just need more time.' James was frustrated with *content heavy* schemes that often "focussed on facts regurgitation, rather than using enquiry learning and practical investigations to develop content understanding and thinking skills.' Beth agreed that their teaching schemes were also content-intensive. There was very heavy emphasis on assessment which James considered and Jane believed transformed the internal motivation from curiosity and mastery to the external motivation of getting good grades. In Sam's and James' view the combination of assessment focus and drive for grades was having a detrimental effect:

I have a top biology student in Y12 who told me that she hated the gas exchange topic because it was "useless." She said, why would you need to know how the spiracles of insects work in any real-life situation? I found this really concerning because adaptation is the key concept of biology and it helps to explain a lot of other concepts and helps to build the big picture. A top inquisitive student who has lost the appreciation for the wonders of the natural world while taking on a utilitarian approach to learning is probably the saddest thing I can think of. (James)

James quoted Pablo Picasso and said 'Every child is an artist. The problem is how to remain an artist once we grow up.' With a sigh, James added, 'my challenge is to keep those who are able and curious wanting to be interested in science.' Beth was also concerned about time but for both herself and the students. She said, 'Just time, my finding time and these students in my school have more out-of-school commitments (debating, sport, dancing, you name it!).'

Sam (who also teaches mathematics) was concerned about students who were exceptionally able: 'really good and I try to help them out':

There are some international students in year 11 and 12, standout great mathematicians, Asians, who I couldn't help because they have been here only a short time and they struggle with English. They are high-ability students too, I *guess I help them a bit, but not sure that we are addressing their learning needs.*

Jane was concerned about her special needs class. She had asked for them all to be in one science class. Every child in the class had learning needs:

So, there's a lot of autism and dyslexia, dyscalculia, dyspraxia. A lot of anxiety, a lot of eating disorders as well in that class but the students are NOT [emphasis is original] low-ability. About a third of the class could be performing at the top end and after getting past their learning issues most are beginning to believe that they can achieve. It has taken half a year for them to learn strategies to manage their learning difficulty but now they are experiencing success. I like that, and I am loving it!

Sam is sometimes puzzled that a student gains an Excellence in one topic, and gains Merit or even just an Achieved in another:

It's like I'm used to someone who's really good just getting excellence in everything, for example Tim just loves maths but there are others who are very capable, they can do it but they don't seem to have a passion for it. I do not have the top maths class but would love to have the opportunity to teach a class of highly able mathematicians who LOVED maths. In the school where I trained I did teach a year 10 high-ability class, it was just wonderful. They just picked things up. They understood things. You could enjoy the beauty of maths with them because they understood and could see it.

School approaches to addressing learning needs

Two schools had some form of streaming and students in the year 10 accelerated learning class could do mathematics with the year 11 class. It appears it is too difficult to try multi-level teaching across all subjects in a large school. There was no provision for acceleration in two out of the four schools where these teachers were then teaching. Jane's school had a homework club which students could attend for extension or catch-up, or whatever they needed. In James's school, acceleration was an option for year 10 and 11 students in mathematics. James had also developed an electronic learning guide for each lesson. His more able students could work their way through the easy questions very quickly and then start tackling the more difficult ones which required them to research more information or to combine different concepts. This was an enrichment programme he was developing that had captured the interest of his senior biology students.

Beth's school offered all students the opportunity to become involved in science competitions and although she encouraged her more able students to participate, only a few did.

James and Jane did not know of any enrichment programmes in their schools but wanted to set up Creativity in Science and Technology for their students. This programme is organised by the Royal Society of New Zealand and offers three levels of projects – Bronze, Silver, and Gold – that students can work on with support from practising scientists.

Discussion

Our findings reveal that all four participating teachers were aware of the learning needs of their high-ability students. None of the teachers was satisfied with the time they had available to focus on planning and working with their high-ability students. From the results, we have identified emergent themes which we have discussed in light of the extant literature.

Although New Zealand has guidelines for meeting the needs of gifted and talented students, our participants had not seen the policy documentation in their schools. While their comments suggest that they were trying to address the needs of their high-ability students, an awareness of the policy might well have encouraged the teachers to consider additional means to support the students and to seek guidance from other teachers. It is noteworthy that content in their initial teacher education courses touched upon students with special needs, including those with high ability, but did not cover it in depth. Beth had taken an additional course in Gifted and Talented education and she said that what she had learnt there she applied in her teaching practice.

The teachers had worked out their own way of identifying the more able students. Each mentioned using the PATs, which all juniors participate in at the start of the year. PATs are used to identify high-ability science students but they are not *science tests*; they are English and mathematics tests. Using these tests for streaming may disadvantage the more able science student who may be weak in English or advantage those who are strong in mathematics. Further, these tests to stream classes do not necessarily identify high-ability *science* students. This was commented on by Sam who acknowledged that just because his student was exceptionally able in one aspect of mathematics, it did not follow that he would be just as good in another aspect. Teacher comments suggested that they thought this selection process was a *blunt tool*, but the best they had access to. Teachers' use of PATs also indicates that the PATs are valued as *standardised* tests with high reliability, an aspect that is constantly reinforced when they are asked to cite evidence. Borland (2009) highlights the need to use tests that are valid for selection of high-ability students and our findings suggest that such tests are not current practice in these teachers' schools.

In accordance with Renzulli *et al.* (2009), the participating teachers used some of the behaviours demonstrated by gifted science students such as creative thinking, enthusiasm for learning science, curiosity, interest in science, and competence in investigative skills. Taber & Riga (2007) advocate the use of a range of characteristics for identifying high-ability students in science. However, the participants used their teacher knowledge of such behaviours and were not using instruments available to measure them in any way. They relied on their own criteria, which could be considered teacher nomination as recommended by Kornmann *et al.* (2015).

The teachers said they used pedagogical approaches that challenged students to think, to be curious, and to ask questions. One could argue that these approaches are useful for all learners, and indeed they are. It appears that the teachers believed the pedagogical approaches they used were important to extend the high-ability science student and all tried to incorporate these in their teaching. Beth's approach was to present the learning as a problem, and in her opinion this challenged the more able learner, a view that is supported by Taber & Riga (2007) who consider problem-solving to be one of the behaviours of high-ability students in science. That said, most participants had good intentions to provide for these students but all acknowledged they did not have the time to thoughtfully plan for teaching high-ability students. James mentioned incorporating tasks that would enable high-ability learners to develop a nuanced understanding of the NoS recommended by the curriculum and by scholars for high-ability students (see, for example, Gilbert

& Newberry 2007; Taber 2016). Sam talked about his student Jim going to the philosophy club, which Sam also went along to, but there was little evidence of other students learning anything about the philosophy of science.

Another interesting finding was that each participating teacher had their own interests and that is what they focused on. Jane was exceptionally good at identifying the requirements of students who had special learning needs and was supporting this group of students. James, who had recently completed his teacher education course, was keen to help students to develop an understanding about the NoS. Beth, who had an interest in gifted students, provided challenges for her students, and framed her lessons around problems that needed to be addressed.

Having the opportunity to engage in authentic scientific inquiry is promoted as an important aspect in the development of scientific thinking, creativity and reasoning (Osborne 2014, 2017). We did not find any evidence of the teachers engaging their students in authentic scientific inquiry to enable them to come up with their own questions to investigate. Scientific inquiry – and practical work in general – has been regarded as a commonly used pedagogical approach in science (Hodson 2014; Millar 2004). Only one teacher mentioned using inquiry, and open-ended investigations (recommended by Han 2017; Kaplan *et al.* 2016) that would challenge these students and perhaps motivate them was not general practice. These teachers may well have provided opportunities for all students to engage in practical work but this was not reported as a specific approach for the high-ability students.

Sam and Beth stated that their schools offered an accelerated learning class but they did not teach such a class and had limited knowledge of how students were accelerated. Beth, who had a personal interest in science outside the classroom, talked about some of her more able students attending science-related talks at the Royal Society of New Zealand and said her school offered enrichment opportunities for the high-ability students.

An interesting aspect raised by Jane related to preparing students for assessment. There is no doubt that assessment of learning matters, and perhaps matters more for the high-ability students. Jane felt she was constantly trying to maintain a balance between encouraging thinking and learning and *training her students to perform in assessment*. The current environment in our country appears to prioritise credits and grades in assessment over deeper learning (Moeed 2015).

Teachers' beliefs have a role to play in how the curriculum is implemented in the classroom. These teachers were aware of the need to both identify high-ability students, and provide the best opportunities they could to extend and enrich learning in science while meeting the learning and assessment needs of their high-ability students. They faced the challenge of not having enough time to do as much as they would have liked in terms of planning to teach in ways that would be ideal for the high-ability students.

Conclusions and implication for policy and practice

In this exploratory study we set out to investigate the ways in which participating teachers identify and make provision for high-ability science students, the evidence they use to evaluate the success of the approaches they take, and the possible barriers they face in being able to provide for these students. The discussion shows that, in the absence of familiarity with the mandated policy and owing to limitations of selection processes, the participants used their own beliefs about the needs of high-ability students to make provision for this group of students. They all used tests and assessment to gauge the success of these students. Not having a clear picture of the policies, and a lack of time to do more were the major barriers they identified.

This is an under-researched area that needs a more comprehensive research project to find out if these teachers' experiences are limited to relatively inexperienced teachers or whether they are more common in secondary school science teaching and learning of high-ability students. A concern that was highlighted was whether and how staff are informed about the policy requirements to meet the needs of high-ability students. In New Zealand, recent international tests like PISA have highlighted the poor performance of the lower-achieving students which has been a current focus of the Ministry of Education and schools. We wonder if this focus on low-performing students is impacting on the needs of the high-ability students, an aspect that needs further investigation.

As these teachers have demonstrated, their enthusiasm for science teaching goes some way to overcoming possible barriers in meeting the needs of their high-ability science students. However, given that New Zealand – and other nations – aspire to develop cutting-edge science and technological innovation, it seems critical that focus is given to ensuring teachers have the knowledge, the tools, and the support to ensure high-ability science students remain in the sciences and potentially become the leaders and innovators of the future.

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