International Journal of Science Education

ISSN: 0950-0693 (Print) 1464-5289 (Online) Journal homepage: http://www.tandfonline.com/loi/tsed20

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To cite this article: Susan Poland , Amanda Colburn & David E. Long (2017): Teacher perspectives on specialisation in the elementary classroom: implications for science instruction, International Journal of Science Education, DOI: 10.1080/09500693.2017.1351646

To link to this article: http://dx.doi.org/10.1080/09500693.2017.1351646

INTERNATIONAL JOURNAL OF SCIENCE EDUCATION, 2017
https://doi.org/10.1080/09500693.2017.1351646

Teacher perspectives on specialisation in the elementary classroom: implications for science instruction*

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ABSTRACT

In the current educational climate of testing and accountability, many elementary teachers find they lack adequate time and confidence to enact reform-based science teaching due to pressure to perform in reading and mathematics. With this tension in mind, we explore the phenomenon of elementary teacher specialisation in comparison to the traditional, generalist model of teaching, wherein a teacher is responsible for teaching all subjects to one group of students each year. This mixed-methods study examines teacher perspectives on the practice of specialisation and generalisation through teacher interview data. Our teachers spoke candidly about their attitudes towards specialisation, the perceived impacts of specialization on teachers and students, and the role of accountability, administration, and testing in their decisions to specialise. Additionally, our teachers discussed time dedicated to science in specialist and generalist classrooms. Our findings suggest that specialist roles are sought by those who see specialisation as a means of reducing workload, while allowing for content mastery and improved instruction. Alternatively, generalist roles are sought by those who primarily view the role of elementary teaching as the care and development of children, and who prefer to focus on the classroom as a holistic, fluid space. Implications for science teaching are discussed.

ARTICLE HISTORY
Received 6 July 2016
Accepted 3 July 2017

KEYWORDS
Elementary/primary school; in-service teachers; specialist

The Next Generation Science Standards (NGSS), introduced in 2013 in the U.S., emphasise a need for students to understand not only scientific content knowledge at deeper levels, but also for students to take part in the 'practices' (NGSS Lead States, 2013) of science to an extent not seen in previous standards documents. In order for students to develop the skills outlined in the NGSS, however, high-quality science instruction must take place at the elementary levels so that students may build upon this knowledge in secondary school. Unfortunately, reform-based science instruction rarely takes place in the elementary classroom, and those that enact these types of reforms are frequently considered outsiders going against the grain of traditional school discourse (Carlone, Haun-Frank, & Kimmel, 2010).

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To make matters more difficult, research suggests that many elementary teachers lack preparation to teach science (Epstein & Miller, 2011). Additionally, the amount of time elementary teachers spend on science instruction is limited (Blank, 2013), particularly in states where accountability policies do not attribute much worth to science outcomes at the elementary level due to testing pressures which place emphasis on reading and mathematics (Carlone et al., 2010; Dee, Jacob, & Schwartz, 2013; Judson, 2013). This literature on the structural barriers to teaching science in the elementary classroom suggests that the prospects of increasing both the quality and quantity of science instruction at the elementary level seem bleak given current emphases on reading and math.

However, in the course of conducting interviews with in-service elementary teachers across one U.S. state, we identified an interesting way in which teachers were attending to all four core subject areas (math, science, reading, and social studies) in the face of pressure to perform in reading and math. As we will detail in the following pages, elementary teachers, trained as 'generalists' ready to teach four core subject areas, are becoming 'specialists' in certain subjects through a variety of means and for varying purposes. While specialisation is not a new phenomenon (Lobdell & van Ness, 1963; Seegers, 1947), the enactment of specialisation has been incompletely described in current literature and its relation to science instruction has not fully been explored (Appleton, 2007; Olson, Tippett, Milford, Ohana, & Clough, 2015).

In this study, we present a careful naturalistic examination (Hammond & Brandt, 2004) of the phenomenon of science specialisation as reported by U.S. elementary school teachers. We are concerned with capturing why and how specialisation happens, and for what purpose. As we detail, the roles of specialist and generalist appeal to different teachers in differing conditions, and these roles are almost never selected autonomously – administrative and peer influences play a large role in determining whether a teacher becomes a specialist or a generalist. We discuss the merits of both specialisation and generalisation, as seen through the eyes of our participating teachers, and end by discussing the role that specialisation might play in current elementary classrooms given the push for reform-based science instruction at the elementary level.

Conceptual framework

Defining the science specialist

The research presented in this paper is a part of a larger research project that involved interviewing elementary teachers about the environment in which they teach science. Included in the interview protocol were questions related to the teacher's daily schedule and the time allotted for science instruction. Early in our analysis, we realised that teachers' schedules differed dramatically, and a great deal of this scheduling variability was due to the content the teacher was assigned to teach. Some teachers were required to teach all core subject areas, while others were assigned to teach specific content areas. To differentiate between these groups, we gave teachers one of two labels – 'specialist' or 'generalist.' Teachers who we labelled as 'generalists' (Appleton, 2007) were traditional elementary teachers who taught all four core subject areas to the same group of students throughout the day. Generally, the only moments when these teachers were not with their students were times when students were sent to supplementary courses (such as art or

physical education), lunch, or recess. Teachers typically described this teaching arrangement taking place in a 'self-contained' classroom.

Teachers we labelled as 'specialists,' however, described diverse schedules that in some way gave these teachers the opportunity to 'specialise' in one or more subjects. As specialists, teachers met with multiple groups of students per day rather than the same group of students all day, and provided students with instruction in only certain subjects. Teachers usually described this teaching arrangement as 'departmentalisation,' 'team-teaching,' or 'specialisation.' Our definition of a specialist most closely resembles (but does not perfectly match) Appleton's (2007) description of 'turn teaching by generalists,' an 'informal agreement between two or three teachers to divide subjects between them' (Chapter 18).

It is critical to note that our definition of a science specialist differs from the role of specialists described by Appleton (2007), Jones and Edmunds (2006), Marco-Bujosa and Levy (2016), and Schwartz, Abd-El-Khalick, and Lederman (2000), who envision a science specialist as a teacher who often has extensive training or experience in science or science pedagogies. This type of specialist often provides science instruction that is supplementary to the generalist's instruction. For example, this type of science specialist might serve the entire student body at a school, meeting with every classroom of students once a week for supplementary science instruction in a science laboratory classroom. These specialists might also take on a leadership role in science by providing generalists with professional development or curricular materials intended to improve science instruction. Instead, our specialists are teachers who were trained and hired to be elementary generalists but have taken on teaching duties in specific subjects and are not generally trained to solely teach science.

Science education in today's elementary classroom

Our research on specialisation in the U.S. elementary classroom, and how this phenomenon relates to science instruction, is framed by the tensions that exist between traditional elementary teaching roles and current accountability measures and curricular reform efforts. The field of elementary teaching is traditionally a feminised profession (Forrester, 2005; Galman, 2012; Meiners, 2002), populated by women who are interested in the work of care and development of the whole child (Danielsson & Warwick, 2014; Vogt, 2002). However, the work of elementary school teachers in the U.S. has dramatically shifted due to accountability policies driven by the No Child Left Behind (NCLB) Act of 2001. On top of feeling pressure to care for and nurture students, elementary teachers post-NCLB have been asked to take on new and expanded tasks, like closely monitoring student data and performing managerial tasks (Bridges & Searle, 2011; Valli & Buese, 2007), oriented more closely with a 'masculine culture of management and performance' (Forrester, 2005, p. 284). The expanded, conflicting workloads faced by current elementary teachers have increased teacher stress and reallocated teacher time to meeting external demands, providing teachers with less time to attend to the holistic development of students (Bridges & Searle, 2011).

The pressures of NCLB also reshaped elementary teacher schedules; namely, teachers began devoting additional time to reading and mathematics (Blank, 2013; Carlone et al., 2010; Dee et al., 2013). It is also worth noting that while NCLB changed the teaching

landscape in the U.S., the marginalisation of science in comparison to English and mathematics has also been documented in the U.K. and Australia (Danielsson & Warwick, 2014). NCLB required states to assess math and reading performance annually from grades 3 to 8, but only required science to be assessed once during elementary years. NCLB outlined serious consequences for schools that did not meet accepted performance levels in these subjects. This had the unfortunate consequence of reducing time allocated to science (Blank, 2013; Dee et al., 2013), particularly during years when science is not included in statewide accountability measures (Judson, 2013). Additionally, teachers facing accountability pressures reduce the amount of time spent on hands-on science instructional practices (Hayes & Trexler, 2016). Given that the replacement bill for NCLB, the Every Student Succeeds Act (ESSA) of 2015, stipulates similar reading and math testing requirements, there is little reason to believe that time allocation will change under the new act.

Further exacerbating the marginalisation of science at the elementary level, however, is a general fear of engagement with science by elementary teachers. Elementary teachers are typically not required to take much college-level coursework in science (Epstein & Miller, 2011). Many pre-service elementary teachers also express frustration or boredom with science in their own K-12 schooling experiences (Danielsson & Warwick, 2014). As a result of these experiences, they frequently do not see themselves as 'science people' (Carlone et al., 2010) – people who are interested in, value, and are capable in science – making them less likely to engage seriously with science. Those teachers who do take up reform-minded science identities (i.e. teachers who are 'science people') are frequently ostracised by their peers. Carlone et al. describe these teachers as 'tempered radicals' – teachers who are members of the elementary school community, yet who differ from the mainstream school culture because they have different ideals, goals, or motivations from their peers. As Carlone et al. note, reform-minded science educators in the elementary classroom find themselves 'caught between what teaching and learning means to them and the prevailing meanings of teaching and learning promoted in school' (p. 948). In today's elementary classroom, 'prevailing meanings of teaching and learning' include attending to accountability requirements, which help reinforce traditional schooling traditions and structure school time and resource allocation (Carlone et al., 2010).

Danielsson and Warwick (2014) expanded on the work of Carlone et al. (2010) in a study of the discourse of pre-service elementary educators as they described their roles as elementary teachers and specifically as science teachers. As Danielsson and Warwick (2014) detail, the discourse of the traditional primary school teacher is often in direct conflict with the discourse of a reform-based science teacher. Elementary teachers are influenced by their own experiences of 'traditional' schooling, wherein teachers are seen as nurturers and knowledge authorities who utilise many teacher-centred pedagogies. Many pre-service elementary teachers strive to distance themselves from teacher-centred curricula based on their own frustrated experiences in K-12 classrooms, but are hesitant to take on a role in which they are not knowledge authorities. This has a negative effect on a teacher's willingness to take on inquiry-based pedagogies in which students may ask questions related to topics with which the teacher is unfamiliar. Danielsson and Warwick conclude,

> In particular, the traditional primary teacher Discourse, so strongly associated with social caring, and so prevalent in the student teachers' own educational biographies, might be seen as lacking intersections with the teaching of subjects beyond literacy, numeracy and personal, social and health education. Views of science teaching, particularly 'traditional' science teaching, seem to emphasise this dichotomisation of the traditional primary teacher and science, and this may be further exacerbated by the ways in which the traditional primary teacher is associated with a maternal imagery, whilst science and science teaching are male-dominated and masculinely connotated practices. (p. 123)

Our research methods were designed to attend to the tensions, described by Danielsson and Warwick (2014) and Carlone et al. (2010), elementary teachers feel when trying to enact science in their classrooms. As we will discuss, our teachers echoed the sentiments expressed by the teachers in Danielsson and Warwick and Carlone et al., in their conflicting dialogue of what it means to be a 'good' elementary teacher and what it means to teach science in today's high-stakes elementary classroom. Specifically, our research attends to the ways in which some teachers have made time for marginalised subjects like science by focusing their teaching efforts on specific subjects rather than attempting to teach all subjects.

Methods

Methodological framework

The research presented in this paper was conducted as a part of a statewide professional development programme for U.S. elementary teachers interested in bringing reform-based pedagogies to elementary classrooms. At the outset of the project, our research team became interested in documenting the contexts in which our participating teachers attempted to teach science, all while attempting to understand the life histories of our participants and why they came to our professional development institute. Through our data collection efforts and analysis, we specifically sought to attend to competing pressures of the curriculum, reform efforts, and teacher interest and expertise in relation to science in elementary schools. We wanted to collect a clearer picture of the diversity of ways that science had been taught, by whom, and with what preparation to do so, which required a naturalistic lens.

We proceeded using the lens of educational anthropology, informed by Hammond and Brandt (2004). Hammond and Brandt articulate, to date, the clearest picture of anthropology's contribution to science education research methodology; mainly, that in some cases, naturalistic study is required to better understand a phenomenon rather than prematurely superimpose educational change efforts which may not articulate well with the interests of the community under consideration. As this line of research was solely interested in documenting teachers' perceptions of their teaching contexts, rather than changing these environments, the methods described by Hammond and Brandt served us well. Our lens is not inclusive of Hammond and Brandt's (2004, pp. 10–11) entire list of distinctive practice, as Hammond and Brandt note that all elements of their framework do not need to be included to fit the lens of educational anthropology. Hammond and Brandt propose seven main attributes of an anthropological lens, and note that studies claiming to understand phenomena through the framework of educational anthropology should possess at least three of these attributes. Our research fits four of Hammond and Brandt's criteria,

through our: use of ethnographic methods, which focus on inductive methods and extensive interview data; focus on the context and culture of the science classroom; consideration of traditional gender roles and the way in which this shapes classroom culture; and our attempt to 'give the reader a broad view of the people, context, and cultures that are involved in the social reproduction of an educational system and of knowledge within that system' (p. 11).

Data collection, participants, and analysis

To gain a reading on elementary teacher interest in, engagement with, training for, and professional practice with science in the curriculum, we conducted ethnographic interviews (Patton, 2015; Spradley, 1979), structured to collect a holistic view of teachers life histories, with elementary teachers in a U.S. Mid Atlantic state. These semi-structured interviews had two main components, the first of which focused on the teacher's life history prior to becoming a teacher, including teacher interest and engagement with science and their professional preparation for teaching it. The second portion of the interview focused on the enactment of science in the classroom, including collegial and administrative supports/hindrances to teaching science and the time and conditions placed on teachers as they attempted to teach science. A total of 157 interviews were completed with teachers across the state.

Specific questions related to specialisation or departmentalisation were never asked during the interview protocol. However, after finishing all interviews, transcribing them, and reading through a number of them for recurring themes, our analysis team noticed discussion of specialisation recurring throughout the interview transcripts across many of our participants, without any prompting by the interviewer. (Sample interview questions that elicited discussion of specialisation are included in Appendix 1.) We initially attempted to identify literature related to the phenomenon of specialisation and its relation to science, but found that research has devoted little rigorous focus to this topic over time (Olson et al., 2015).

After realising we had a potentially robust data set to explore this phenomenon, we open coded all 157 interviews for discussion of specialisation. We applied the code 'specialisation' anytime someone talked about the experience or enactment of specialisation or generalisation in the classroom, or expressed an attitude toward either classroom structure. A total of 61 interviewees mentioned specialisation as defined by the code. After identifying this subgroup of individuals who spoke freely about this phenomenon, we developed a written summary that described each teacher's perspective on specialisation or generalisation. These summaries were used as an initial step in our iterative coding process, as we used these to identify emergent themes (Corbin & Strauss, 2008) related to the phenomenon of specialisation or generalisation. After independently coding the summaries and original transcripts, our research team met to discuss our findings. We identified four main recurring dialogue themes across the interviews – how the teacher felt specialisation or generalisation impacts students, how specialisation or generalisation impacts the teacher or the teaching environment, the impact of specialisation on time for science or the ability to integrate the curriculum, and the role of administration in decision-making related to specialisation.

After primary analysis of the specialisation subset, we became interested in how the specialists compared to the generalists. Borrowing from techniques described by

Collingridge (2013), we realised we were able to compare the dichotomous categories we had created of 'generalist' and 'specialist' in more meaningful ways if we transformed our qualitative data into quantitative data (Greene, 2007). We abstracted data from all 157 transcripts related to participants' time teaching science, role as a specialist or generalist, grade level and subject areas taught, and aligned this data in a matrix. This allowed us to identify differences between specialists and generalists in order to further articulate the phenomenon of specialisation in the classroom. In the findings, we present an overview of the differences between specialists and generalists, including tests for significant differences between specialists and generalists in the amount of time spent on science instruction.

We initially attempted to write this paper after conducting this statistical analysis and after exploring the major themes that emerged in relation to specialisation. However, our initial writing process fell flat when we realised we could not accurately capture the complexity of the phenomenon of specialisation by divorcing the experience of specialisation from the whole person involved in specialising or generalising. Our teachers' experiences with science and beliefs about teaching seemed to play a large role in how they felt about specialising or generalising. In order to fully understand this interplay of life history and classroom structure, we returned to the full transcripts from the subset of 61 interviewees who spoke about specialisation to more fully understand, solidify, and contextualise the emergent dialogue themes that captured how and why teachers were specialising or generalising. Two researchers (the first and second authors) read each transcript and met regularly to understand patterns in the data. Building from the best practices outlined by Patton (2015) to enhance the quality of our study, we sought to constantly compare the findings from one transcript to the next. When we identified negative/discrepant cases that did not fit our understanding of the phenomena, we more deeply explored the transcript of this case in tandem in order to broaden our understanding of the interplay between individual background, classroom structure, school culture, and attitudes toward specialisation/generalisation. Additionally, we found that our quantitative analysis triangulated the findings of our qualitative analysis, enhancing our confidence in the quality of our findings (Patton, 2015).

Some of the teachers in this interview subset spoke only briefly about specialisation, while others spoke at-length and in-depth about their teaching practices and rationale for their preference for specialisation or generalisation. We elected to tell the story of specialisation and generalisation through quotations from the respondents who fell into the latter category. While these teachers cannot fully represent the broader pool of teachers who spoke on this subject, these teachers clearly conveyed their attitudes toward specialisation and generalisation to us, and their aggregated stories are representative of the majority of our respondents. We use their comments to convey the findings that emerged over the course of all 61 interviews. By providing both description and quotations, we attempt to provide the balance between description and interpretation advised by Patton (2015), allowing 'the reader to enter into … the thoughts of the people represented in the report' (p. 605).

In the following pages of this mixed-methods study, we present quantitative data abstracted from the interviews to help provide a general overview of the differences between specialists and generalists. The information provided helps us tell the story of one of the main themes that recurred in our teacher dialogue in relation to specialisation

– the amount of time spent on science. We then provide an elucidation of teacher perspectives related to the three remaining themes by providing a brief overview of the breadth of teacher perspectives on specialisation, and develop these themes more fully through the eyes of the teachers who provided us with rich data on the phenomenon of specialisation at the elementary level. The concept of time on science is woven throughout these stories.

Findings

An overview of all interviewees

For the purpose of narrowing the scope of the analysis to classroom elementary teachers, any middle school teachers ($n = 11$) or support specialists ($n = 11$), such as reading specialists, were removed from our analysis of the initial pool of 157 teachers. The remaining 135 participants represented classroom elementary teachers in grades 3 through 6, and these teachers were then further classified by their current, self-reported teaching assignment as a generalist or specialist. The majority of teachers (72%) reported working in what is considered the most common elementary teaching structure – a self-contained, generalist classroom, in which the teacher is responsible for instruction in all core content areas (math, language arts, social studies, and science).

The remaining 28% of teachers reported teaching in a specialist arrangement, a category which was further defined as 'one-subject,' 'two-subject,' or 'three-subject' specialisation according to the number of content areas a teacher was assigned to teach. A complete overview of teaching assignments explored in this study can be found in Table 1.

After the generalist role, two-subject specialisation was the most commonly reported teaching arrangement, with most of these specialists responsible for instruction in either reading and science, or math and science. This was often indicative of a 'homeroom'-based arrangement, where the teacher instructs the homeroom students in math or reading, and then teaches science to rotating groups of students throughout the remainder of the day. A smaller subset of two-subject specialists taught only social studies and science, or a unique combination of subjects not inclusive of science. The permutations of three-subject specialists were even more varied; however, they did follow the general pattern of the teacher responsible for instruction in either math, language arts, or both,

Table 1. Teaching roles defined and accounted for in this study.

Type of teacher	Responsible for teaching …	Number of teachers assigned
Generalist	Science, social studies, reading, and math	97
1-Subject specialist	One content area	4
	Math	3
	Science	1
2-Subject specialist	Two content areas	26
	Science and reading	9
	Science and math	8
	Science and social studies	6
	Other combination without science	3
3-Subject specialist	Three content areas	8
	Science, math, and language arts	4
	Science, math, and social studies	2
	Science, language arts, and social studies	1
	Other – reading, math, and social studies	1

in addition to another subject. It is clear that, in line with current emphasis on math and literacy skills, teachers are infrequently assigned to roles in which they are not responsible for instruction in at least one of these high-accountability, heavily tested content areas.

Time

Along with reporting subjects taught, our elementary teachers reported the amount of time they spent on these subjects, and as we will later discuss, frequently expressed that specialisation protects time for marginalised subjects, like science. We became interested in whether time is actually protected for science in specialist classrooms when compared to generalist classrooms. After abstracting teacher-reported time spent on science from our interviews, a *t*-test was used to determine if time spent teaching science per day differs between specialists and generalists. All specialists (one-subject, two-subject, and three-subject) were condensed into one group labelled as 'specialists' in order to compare mean time on science between all specialists and generalists. Four teachers who did not provide time on science were dropped from this analysis, along with an outlying three-subject specialist who reported teaching science for 90 minutes per day. Analysis revealed a statistically significant difference in average daily time spent teaching science between specialists and generalists, $t(88.85) = -4.48$, $p < .001$, with a 95% confidence interval of -15.43 to -5.94. Specialists spent an average of 10.68 additional minutes on science than their generalist peers, leading us to conclude that specialisation does protect time on science. Table 2 displays descriptive statistics related to the amount of time spent on science by each type of teacher. Though the sample sizes for all specialist groups are small, our data also suggest that specialising reduces the variability in the amount of time spent on science. The range and standard deviation measures are larger for generalists than specialists due to the great variability in the amount of time generalists spend on science. This is indicative of the varying school contexts in which generalists attempt to teach science which do or do not provide the adequate time for science to be taught.

It is also of note that the majority of the 38 elementary specialists are upper elementary teachers, specifically fifth-grade teachers ($n = 18$) or fourth-grade teachers ($n = 9$). Teachers often reported their grade-level assignment in tandem with their role as a specialist, indicating that this arrangement was appropriate due to the student's grade level and attendant developmental readiness. Even fervent specialists were likely to question the practice of departmentalising in the primary grades, K-2, citing it as developmentally inappropriate for these students to see more than one teacher per day or switch classes.

Table 2. Time on science per day for specialists and generalists.

					Range	
Teacher type	*N*	Mean	Standard deviation	Standard error	Minimum	Maximum
Specialists (all)	37	45.73	11.05	1.82	20	75
1-Subject	4	60.00	12.25	6.12	45.00	75.00
2-Subject	26	45.65	9.29	1.82	30.00	65.00
3-Subject	7	37.86	9.51	3.60	20.00	45.00
Generalists	93	35.05	14.92	1.55	2.70	75.00
Total	130	38.09	14.71	1.29	2.70	75.00

Notes: Reported time on science is an average amount of science reported by the teacher. The amount of time spent on science was averaged for teachers who did not report teaching science daily or who reported varying amounts of time spent on science (e.g. 'I teach science for 30–40 minutes per day').

Opinions about specialisation in the middle ranges of grades 3–4 varied significantly depending upon teacher background, interest, and prior experiences.

Perspectives on specialisation and generalisation

Teachers discussed their experiences and viewpoints about topics related to these themes most often from the perspective of their current teaching assignment; however, a minority of teachers categorised as 'would-be' specialists or generalists emerged from the coding and offered unique perspectives. As such, teacher perceptions toward self-contained or specialised classrooms varied by current position, personal experiences, experiences of colleagues, and interest in science. The majority of teachers expressed definite opinions toward one schedule configuration, while a minority of teachers had experienced both arrangements and were split between no preference and a strong preference in either direction.

As expected in accordance with the general population of U.S. teachers, the majority of teachers included in this study identified as generalists, or teachers who provide instruction in all subject areas to a self-contained classroom of students. Due to the prevalence of this traditional elementary classroom configuration, even those teachers who were currently acting as specialists, whether in science or some other subject, had usually been a generalist at one point in their teaching career. As such, there were a variety of teacher perspectives on the generalist classroom arrangement, representing perceptions of current generalists, past generalists, and 'would-be' generalists. Those who disapproved of specialisation, or simply preferred the self-contained classroom, were in the minority of the subset; however, current generalists were more likely to hold negative perceptions of specialisation, while current specialists were less likely to express a negative view of the practice.

Perhaps unsurprisingly, the majority of specialist teachers spoke out in favour of specialisation or departmentalisation in the elementary classroom (82% of the specialists who spoke about this topic). However, they were not alone in their perceptions of specialisation. Current generalists described their own experiences with, or their observations of specialisation, and the majority of them (63%) reported being in favour of the practice to varying extents.

In the following pages, we further elucidate the phenomenon of specialisation, utilising the perspectives of the participating teachers who spoke at-length and in-depth about the phenomenon of specialisation. Their comments are arranged according to emergent themes identified through our analysis: teacher attitudes toward specialisation, the impacts of specialisation on students and teachers, and the role of accountability, administration, and testing.

Attitudes toward specialisation

Teachers most committed to the generalist classroom arrangement spoke frequently and passionately about their approach to teaching with a focus on pedagogy, sometimes viewing teaching as an 'art' or as a 'first love' as one lifelong generalist, Wendy, expressed. Similar sentiments were echoed by Deanna, who describes teaching as her 'biggest passion.' Her excitement and commitment is evident as she further explains how she views her practice,

> I live, I breathe, everything is what can I do better? What can I do different? What's a new way of teaching this? And I think that's why I stayed in third grade as long as I did, was because every year, I'd find something new to do.

Generalist teachers prefer the 'connection' and 'bonding' that they describe as inherent to the self-contained elementary classroom. Deanna explains, 'It's that family, and you're with them all day long.' Wendy elaborates further,

> You're not just helping kids with academics. Particularly in elementary school, you're helping them deal with the social aspect. How to – how do we deal with each other when we have a problem? What do I do if someone's doing something mean to my friend? What do I do if I'm mad at my teacher? It's nice to see that and help them grow in that way.

These attitudes align well with previous research which describes the traditional approach to elementary teaching as centred around the care and development of children first and foremost (Vogt, 2002).

Specialist teachers were not drastically different from their generalist colleagues in terms of general attitudes toward the practice of elementary teaching. The focus on the care and development of children remained; however, with slightly more of a balance between the emphasis on the ethic of care traditionally associated with elementary practice (Vogt, 2002), and an emphasis on a passion for content and mastery. Laura, a current generalist but 'would-be' specialist, illustrates this specialist perspective in her explanation of her transition from her position as a ninth grade science teacher to a fifth-grade elementary teacher. Laura says,

> I still live in this rose-colored world, where education should be loved and interesting, and the kids should want to be there. I had to find a group that still wanted that, [but] where I could still do a little bit more advanced things.

This sentiment is indicative of the balance between content mastery and care many specialists seek, especially those with a passion for a particular content area, such as science.

A notable difference in the specialist perspective arises in that specialist teachers do not perceive the need for students, especially those in upper elementary grades, to remain with one teacher for the entire day. Specialists are aware, however, that many teachers who prefer the generalist classroom do not share their opinion. Rick explains that elementary teachers in his school are 'possessive of their kids,' and do not see the converse of the situation from the specialist's perspective. Rick explains that when he was departmentalised in the past 'they all become your kids so I knew every single fourth grader, every single third grader. Now I don't know any of the kids other than the kids in my room.' Mary, a one-subject specialist, confirms Rick's sentiment, as she perceives specific benefits to upper elementary students who switch classes as a result of departmentalisation. She explains that departmentalisation is 'beneficial for the older kids' as content across subjects becomes more challenging, and students are beginning to prepare both academically and developmentally for middle school and beyond.

Impacts on teachers and students

While those who preferred the generalist role primarily centred their dialogue on the academic and developmental needs of students, they also addressed some of the impacts of the self-contained classroom on teachers. A few recurring dialogues emerged here,

namely the teachers' preference for the challenge of teaching all subjects, knowing the entire grade-level curriculum in its entirety, and the flexibility which the generalist classroom affords for instruction and integration of content. Sara, a one-subject specialist, explains her preference for the generalist classroom as she describes enjoying the 'challenge of teaching all subjects,' and Wendy describes her aversion to what she perceives as the monotony of teaching the same subject 'over and over' as a specialist. Perhaps the most poignant perspective, however, is offered by Deanna, who describes her educational journey and ultimate decision to remain a generalist,

> … after getting my master's in reading, I decided against [becoming] the reading specialist because I would have missed the social studies and the science and the math. And I think I like teaching a little bit of all of those. And I like being creative in those areas.

The concept of the role of creativity, art, and passion in the generalist classroom points to the holistic view of teaching and learning that teachers describe as a natural aspect of the more traditional, self-contained classroom. Teachers combine these aspects of their teaching with what they perceive and describe as the ability of generalist teachers to know their students more deeply, and to therefore be able to create a classroom environment specifically tailored to the interests and abilities of that particular group of students. This perspective is affirmed and extended by Joann, who notes that 'departmentalised teachers only know their subject, and not what a student should know generally on grade level.' This assertion is often repeated in support for the self-contained classroom, as the generalist teacher has the control and flexibility required to use their knowledge of their students and the grade-level content to make cross-curricular connections and integrate lessons accordingly.

Additionally, the concept of the self-contained classroom as a place where teachers are increasingly pressured to 'do it all,' 'be expert at everything,' or a 'jack of all trades and master of none' recurs consistently across teacher dialogue, regardless of roles as specialist or generalist. Tammy, a current generalist, notes that she,

> … prefer[s] the departmentalized, the team teaching, only because I feel like if you can break it up and focus more on one or two subjects, I felt like I did a much better job. Being self-contained, many days, I felt like I was a circus performer.

Rick picks up the thread of Tammy's description, as he explains that he finds it unlikely that even the 'best' teacher can adequately cover all tested content areas that a generalist is responsible for teaching; in his opinion, 'something is going to suffer.'

These teachers feel that the specialist approach directly benefits both the teacher and the students, especially under the current climate of testing and accountability. Kelly, a two-subject specialist, 'can't imagine getting students ready for [state tests] in all of the subjects' if she were required to teach in a self-contained classroom. She views being able to specialise as a way to reduce her own personal and professional stress, while also affording students the chance to receive dedicated, masterful instruction across content areas, including science.

The workload associated with planning and data management across all tested areas is both frustrating and daunting, leaving many to support a specialist approach which naturally narrows the scope of content a teacher is responsible for, and allows opportunity for developing mastery in that area. As Laura puts it, 'It's tough, being an expert at everything.

I think that's the one hardship with being in elementary school. I think we need to start being experts in something.' Allowing and encouraging expertise to develop can be a boon to elementary teaching, as Laura illustrates. Despite her role as a 'would-be' specialist, working within the constraints of a generalist classroom, where she notes her time for science has been considerably reduced, she explains that, 'At least to get the kids doing experiments, what I'll do is, I'll set everything up and put it on a cart. I'll say [to the teachers], "Here's everything you need. Here's the lab." … If I set it up they might do it.'

If given permission from his principal, Rick explains a bit about why he would choose to specialise. He describes specialisation as an opportunity to improve the quality of his instruction through consistent engagement with the content, and to reduce the workload of planning for so many subjects every day. 'If I do that in a science lesson, I'm not teaching it again for another calendar year you know?' When asked about the lack of permission to specialise, Rick explains that he needs not only his colleagues, but his administrators, to buy in to the arrangement, a recurring issue which is discussed further in the following section.

Accountability and administration

The enthusiasm expressed by fervent generalists does not mean, however, that each generalist classroom teacher is willing or able to attend to each subject equally and with total mastery; the desire to rise to the challenge of being expert across content areas is not a guarantee of equal emphasis across content for a variety of reasons. Despite the adoption of more rigorous elementary science standards by many states, emphasis on reading and math often prevails as accountability pressures divert attention to performance in these subjects, often limiting the amount of time spent on marginalised subjects such as science.

The generalist approach, as evidenced in many interviews, is often accused of science avoidance due to lack of adequate preparation and personal interest, all compounded by administrative pressures. This is not entirely true, however, as generalists Deanna and Wendy both describe so candidly. Wendy explains that she is now known as a science person in her school, she is considering applying to be a district-level science specialist one day, and she describes science as a 'priority [to her], but not to the administration.' This confidence to pursue science education and to prioritise science teaching was not always a given, as she explains, 'going into teaching I knew that [science] was my weak spot, and the only way to get better is to get educated.'

Deanna also admits,

> If you think of [my] classroom, science is probably not going to be the first thing that pops into your mind … science I'm not confident. The funny thing about it, science is my worst subject. I don't get it. I don't understand it. And I think partly that's why I'm here [at this PD], is to become a better teacher at that.

While the generalist arrangement itself does not guarantee protection of time for science, it is evident that there are generalist teachers who are dedicated to improving their own science confidence and professional pedagogy, in an effort toward engaging and preparing their students to become engaged science learners. The generalist perspective emerges as an arrangement that allows teachers to focus on child development, and to attempt to create a holistic learning environment which they perceive to be integrated and relevant

to interdisciplinary themes. Deanna and Wendy are evidence that some generalist teachers acknowledge and rise to the challenges inherent to the responsibility for teaching all subjects under the pressures of accountability, testing, and administration.

Protecting time for science is a major consideration of the specialist perspective. In contrast to the generalist approach, specialist teachers were more likely to elaborate on the restriction of time on science by testing, scheduling, and administrative constraints. Mary noted that in her past role as a generalist, when the students did not switch classes, 'time just shrank up for some reason.' This is a view of the other side of the generalist perspective, which advocates for a self-contained classroom where flexibility and extension of lessons as needed is a key element. From a specialist perspective, extended lessons too often occur in the form of math or reading, and often at the expense of science. Mary explains further that as a generalist teaching science, the science activities she felt were most meaningful and enjoyable were those that took the longest, and they 'didn't have the time for it.' Clearly, specialising in one or two subjects protects time for science, especially in grade levels which are not tested in science. Laura notes that,

> You're told … that [state test] doesn't matter. It does. It's huge. You are identified 99 percent as a teacher by that. I was willing to take that risk. I just felt, I could do better, I was able to do more, by setting up that science activity three times a day.

The decision to specialise, however, is not always up to the teachers involved, even when there is evidence that a specialist approach would be the best utilisation of a teacher's strengths and interests. Laura continues on to detail her struggle with administration in her pursuit of becoming a science specialist; she explains,

> I wish we had a voice. I think that the principal … decides what we want to do. She wants to be self-contained … I've got to wait until she retires … when the [new] principals come in, will they be talked to about the importance of managing your schedules, and balancing your teachers' talents to that? I think that's where it begins.

Discussion

The phenomenon of specialisation, as we have heard from our interviewees, takes on a wide variety of forms for a wide range of purposes. The teachers we interviewed frequently held multiple views of specialisation, expressing that both generalisation and specialisation have their own advantages and disadvantages. By the end of each interview, however, most of our in-service teachers had expressed a clear preference for one arrangement over the other. In general, specialisation appears to appeal to teachers who appreciate the relative structure of a specialised schedule, value the ability to focus their planning time on one or two subjects, wish to develop mastery in specific subjects, and enjoy seeing multiple groups of students each day. Generalisation seems to appeal to teachers with alternate perspectives of the elementary classroom – teachers who prefer schedule fluidity, who relish the challenge of teaching all subjects, and value spending all day with the same group of students. Our data also suggest that even if teachers have strong beliefs about the merits of specialisation or generalisation, many teachers do not have the opportunity to provide input at the administrative level in the decision to specialise or generalise. The beliefs of the administration carry tremendous weight in the decision to specialise or generalise, and many teachers feel their voices are unheard in the decision-making process.

We are aware that a major limitation of the data presented above is self-reported data, and our data cannot measure the quality of science instruction that takes place in specialist or generalist classrooms. We also cannot claim that the generalist teachers in our sample especially dislike or avoid science, as the teachers in our study self-selected into a professional development programme designed to improve science pedagogy, which means that our sample is already likely amenable to science. We note that some of the exemplary generalist teachers highlighted in our findings are strong advocates for science teaching, and these teachers demonstrate that it is certainly possible to embrace science at the elementary level, even in the face of competing pressure not to do so (Carlone et al., 2010).

Our data do indicate that time on science is better protected in specialist classrooms, however, which provides teachers with the necessary time to enact reform-based science pedagogies, or at the very least, teach science content when generalists might be tempted to push science aside. Carlone et al. (2010) document that teachers can, over time, become 'science people,' who embrace and value science, but this process of becoming a 'science person' involved interacting with science and bringing the excitement of science to students in the classroom. Importantly, specialisation disallows the possibility for science avoidance that generalists face. We do not assert that generalists always intentionally push science to the side, but the generalist structure enables science to be pushed to the side, whether due to time constraints, administrative pressures, or fear of engagement with science. As one of our interviewees mentioned, the intersection of administrative pressure to perform in other subjects, combined with a fear of science, can lead to negative consequences for science at the elementary level:

> There is a lack of science teaching unless administration and the district puts an emphasis [on science]. If they don't put an emphasis on it, you're not going to see science because for whatever reason, I'm not sure why, a lot of the teachers I encounter are afraid of teaching science.

To make science a priority in the elementary generalist classroom requires the willpower to dedicate time and resources to science, against the prevailing culture of the school that favours emphasis on reading and mathematics, also found in Carlone et al. This is not a serious problem faced by science specialist teachers, as they are in roles which explicitly permit them to allocate their time and efforts to science. Providing time and fostering interest in science at the elementary level, whether it stems from a generalist or specialist teacher, is crucial to developing effective and engaging elementary science instruction.

We are interested in the idea that science specialisation permits teachers to build positive science identities in the face of competing pressure from traditional elementary teacher discourse to do otherwise (Carlone et al., 2010; Danielsson & Warwick, 2014). If we, as science educators, value the push for reform-based science education at the elementary grades, it seems necessary to help educators come to see themselves as 'science people.' Many of the teachers in our sample noted that they currently have little access to quality science professional development. Given how much time elementary teachers currently spend on managerial tasks (Forrester, 2005; Valli & Buese, 2007) and monitoring student progress in reading and math (Dee et al., 2013), it seems unlikely that generalist teachers have much time to focus specifically on science content and pedagogy. By specialising in science, teacher workloads are reduced so that elementary teachers can engage more fully with science and focus on quality science curricula.

We again remember that there were generalist teachers who felt they identified strongly with science. It is not impossible for generalist teachers to embody a positive science identity in today's elementary classroom, but it does require 'struggle' (Carlone et al., 2010) to negotiate the dissonance between the teacher's interest in science, traditional notions of schooling (Danielsson & Warwick, 2014), and the prevailing elementary climate of accountability and testing (Forrester, 2005; Valli & Buese, 2007). Administrators have the ability to relieve some of this pressure from generalist teachers by allocating dedicated time for science. We feel that quality science instruction can happen in specialist and generalist classrooms, especially considering that specialists typically have no formal training in science above and beyond that of generalists. However, the degree to which the administration pushes teachers to reallocate time and resources to reading and math has a serious impact on the ability of generalists to teach science effectively. Like Marco-Bujosa and Levy (2016), we encourage school leaders to consider any elementary teaching model with care, and note the pivotal role of leadership in establishing a place for science in the elementary curriculum.

In sum, if we wish for elementary teachers to seriously engage with reform-based science pedagogies, teachers must have the time and space to do so. While we wish that all elementary teachers had this supportive environment in which to engage with science, it is unfortunately not the reality of the elementary classroom of today. We see subject specialisation as a possible way to allow some elementary teachers to engage deeply with science, helping them develop confidence in teaching science and providing them with dedicated time to provide science instruction to their students. This teaching arrangement provides teachers who have strong science identities/wish to develop strong science identities the space to do so. Generalists are also fully capable of developing these identities and frequently long to do so, but many do not feel they can allocate enough time to science because of competing pressure to teach math and reading. The specialist arrangement reserves time specifically for science, and we can hope that this additional time for engagement with science is good for both students and teachers.

Going forward, we encourage the international science education research community to more fully explore the phenomenon of specialisation to understand the impact of generalist and specialist models on teachers and students. We feel that this research has opened many doors to possible fruitful lines of research that could more clearly understand the impact of either classroom structure on teacher confidence in teaching science, teacher content knowledge, and most importantly, student understandings of science. We would like to know more about how best to support elementary teachers utilising either model. Additionally, we encourage the research community to continue to document the ways in which teachers and administrators are and are not attending to science at the elementary level in the face of pressure to perform in reading and mathematics. Carefully constructed quantitative, qualitative, and mixed-methods studies could help educational practitioners make better-informed decisions in the future on the use of the specialist model in their respective schools.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the U.S. Department of Education, Investing in Innovation (i3) Program [grant number U396B100039].

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Appendix 1.

Interview questions which frequently elicited discussion of specialisation/generalisation

- Since graduating from high school, can you please walk me through your work experience?
- Are you or your colleagues pressured to focus on some things more than others?
  - Who applies this pressure?
  - Given this pressure, do you think there are subjects or teaching styles that are not given appropriate attention in your school?
- How is the time for your daily instruction of different subjects and other teacher duties established for your school?
  - Who sets the schedule?
  - Describe your schedule.
  - How much time is allotted for science instruction either alone or integrated across other subjects?
- When is science currently taught in your classroom?
- When is science currently taught by other teachers in your school?
- In what ways is science taught well in your school?
- In what ways can science education be improved in your school?
- How do state or federal testing requirements affect how your school handles the teaching of science?