Journal of Mathematics Education
2024, Vol. 17, No. 1, 38-51

https://doi.org/10.26711/007577152790173

Navigating the Coding Frontier: Teachers' Experiences in Grade 9 Destreamed Mathematics Classrooms

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The introduction of coding as part of the Grade 9 destreamed curriculum marked a significant change, and teachers expressed varying levels of comfort and experience with this addition. As part of the Grade 9 Destreamed Mathematics Research Project, this study examines teachers' perspectives on their instructional practices, self-efficacy in teaching, and the challenges and strategies involved in implementing the Grade 9 mathematics curriculum. Specifically, it explores mathematics teachers' experiences with integrating technology into their classrooms and their initial comfort and familiarity with coding. Findings indicate a diverse range of coding proficiency among teachers, generally low confidence in teaching coding, concerns about balancing time constraints with an already demanding curriculum, and a shared recognition of coding's importance for students' future success.

Keywords: mathematics education, destreamed curriculum, computational thinking, coding, teacher perspectives

There has been a noticeable shift toward the explicit inclusion of one of the essential 21st-century competencies, *computational thinking*, in K-12 education curricular revisions. Computational thinking (CT) is the "thought process involved in formulating problems and their solutions, so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (Wing, 2011, p. 20). It is a fundamental skill that requires analytical thinking and shares close connections with mathematical thinking, engineering, and scientific practices (Wing, 2008). In relation to mathematical thinking, for students it refers to the ways in which they can operate to engage with mathematical ideas (Hackenberg et al., 2021; Lesh & Yoon, 2004). Although there are many ways to develop mathematical thinking, programming has been shown to positively facilitate students' mathematical thinking through programs such as Scratch (Calder, 2018;

Olsson & Granberg, 2022). Consequently, research on CT has received increasing attention, notably in the integration of CT in K-12 mathematics education (Bocconi et al., 2016; Bocconi et al., 2018; Gannon & Buteau, 2018; Swaid, 2015; Wu et al., 2020; Ye et al., 2023). The fact that incorporating programming into mathematics education has many potential benefits is not a novel idea (Benton et al., 2017; Papert, 1980). Learning mathematics using CT can be traced back to Papert's *Logo* programming (1980), however, in recent years CT-based mathematics instruction has become more widely adopted within K-12 contexts, further supporting the prospect of its implementation in classrooms (Grove & Yadav, 2020; Miller, 2019; Pei et al., 2018; Shumway et al., 2021).

The curriculum for Ontario schools recently started emphasizing coding and emerging technologies. In 2020, the Ontario Ministry of Education introduced a series of coding expectations as part of the Algebra strand in the Grade 1 to Grade 8 Mathematics curriculum (Ontario Ministry of Education, 2020). The Curriculum and Resource document explains how the concepts are learnt as a progression: Grades 1-3 include solving problems and creating computational representations of mathematical situations by writing and executing code, inclusive of code that involves sequential, concurrent, and repeating events as well as describing how changes to code affect the outcomes; Grades 4-6 include writing and executing efficient code, inclusive of creating code and altering existing code that involves conditional statements and other control structures; and Grades 7-8 include creating computational representations of mathematical situations by writing and executing code, inclusive of code that involves the analysis of data in order to inform and communicate decisions. Then, in 2021, the Ministry of Education introduced the Grade 9 destreamed curriculum, which also embeds coding expectations into the Algebra strand (Ontario Ministry of Education, 2021). In Grade 9, students are expected to create code by decomposing situations into computational steps in order to represent mathematical concepts and relationships, read code to predict its outcome, and alter code to adjust constraints, parameters, and outcomes representing similar or new mathematical situations. Recently, in January 2024, Education Minister Stephen Lecce announced the province would be revamping the 2016 kindergarten curriculum (DeClerq, 2024). Part of this curriculum will include expectations for coding.

With the prompt integration of coding into the curriculum, teachers are faced with the challenge of learning how to implement coding and teach it to their students. To understand how to help mathematics teachers integrate coding, it is important to also understand teachers' attitudes towards coding in a mathematics classroom. Ahern (2009) found that teachers at the beginning of their one-week summer workshop were resistant to the idea that coding integration could benefit learning. Their attitudes changed however when the workshop instructors showed them how to develop programs and models on their own as instructional tools to include in their everyday lessons. Adler and Kim (2018) also found that their participants did not start training with positive thoughts but showed that even a single-day workshop positively impacted participants' attitudes toward coding. In addition, several studies showed that when teachers became familiar with coding concepts, applied what they learned in their coding professional learning sessions, and integrated coding into their classrooms, their confidence spiked (Chalmers, 2018; Cooper et al., 2011; Holmes et al., 2018; Kay & Moss, 2012; Marcelina et al., 2018).

The Grade 9 Destreamed Mathematics Research Project

The largest school board in Canada and the Ontario Institute for Studies in Education (OISE), University of Toronto, have been partners in a multi-year project with grade 9 mathematics teachers (2021-2024). The purpose of the project was to explore mathematics instruction and assessment in Grade 9 mathematics classes. The research study focused on teachers, and their perspectives on their role in the classrooms, instruction, and assessment in mathematics, and their self-efficacy in teaching the Grade 9 mathematics course. The project adopted three objectives: (a) to investigate best practices, pedagogical strategies, and challenges in implementing destreamed mathematics curriculum, (b) to develop case studies of teachers who are teaching destreamed mathematics courses in Grade 9, and (c) to refine the existing Ten Dimensions of Mathematics Education framework for use in destreamed secondary mathematics programs. To address these three objectives, the research project investigated the following: (a) What strategies do teachers employ to cater to a wide range of student abilities in their destreamed Grade 9 mathematics course? (b) What challenges do teachers face teaching these courses? (c) What resources and support do teachers need to teach students in destreamed Grade 9 mathematics classrooms? (d) Working with teacher insights and research findings, what professional development activities will be most effective to support their teaching of destreamed Grade 9 mathematics courses?

The first year (2021-2022) of the Grade 9 destreamed mathematics research project was the same year that the new destreamed curriculum rolled out. Teachers faced a lot of uncertainty and adversity when implementing the recently created destreamed curriculum as it was released in June of 2021, with no teaching models/examples and no professional development offered. In response to teachers advocating for further professional development, our research team offered a series of professional learning sessions on how to implement the Grade 9 mathematics (MTH1W) curriculum the following year (2022-2023).

One common theme that emerged from those professional learning sessions was the teachers' desire to gain support in learning coding and how to integrate it in their classrooms. This led our team to respond with professional learning sessions (2023-2024) on computational thinking in Grade 9 mathematics courses and the implementation of coding in their mathematics classrooms. This article described mathematics teachers' experiences with integrating technology in their Grade 9 mathematics classroom as well as their early experiences and comfort with coding.

Methodology

This study employed a qualitative approach to examine Grade 9 mathematics teachers' perspectives on their instructional practices, self-efficacy in teaching, and the challenges and strategies encountered in implementing the destreamed curriculum, aligning with the core aim of qualitative inquiry to understand lived experiences (Johnson & Christensen, 2016). Focus group methodology was adopted in this study to gather shared experiences during professional learning sessions. Focus groups are a valuable qualitative research method that facilitate in-depth exploration of participants' shared experiences, beliefs, and perceptions within a group setting (Morgan, 1997). The dynamic interactions among participants allow for the emergence of collective insights that may not surface during individual interviews. This study was also supplemented with case study methodology (Merriam, 2009; Yin, 2014). Case studies enable detailed exploration of phenomena within specific contexts, producing context-rich knowledge through interviews and discourse analysis (Given, 2008).

Participants in this study included in-service secondary mathematics teachers teaching Grade 9. A total of 23 schools participated in this research, involving over 35 teachers. Purposive sampling ensured participants met specific criteria: (a) they were secondary school mathematics teachers, (b) employed in publicly funded schools, and (c) had experience teaching destreamed Grade 9 mathematics for at least one semester.

Data were collected using focus group discussions and semi-structured interviews to achieve a comprehensive understanding of teachers' beliefs, practices, and challenges. The focus group sessions were conducted during the first coding professional learning session, with 13 groups of three to four participants each. Discussions lasted approximately 30 minutes, fostering a team environment to explore collective perspectives. Each group nominated a notetaker responsible for completing a survey that documented key points and responses from the conversation, adding an additional layer of data.

In addition to focus groups, three participants engaged in one-on-one semi-structured interviews lasting 30–60 minutes. These interviews were conducted online via Microsoft Teams and were audio recorded for accuracy. The interviews explored teacher beliefs, experiences teaching the Grade 9 mathematics course, best practices, and challenges. Recordings were transcribed verbatim using Otter.ai, followed by manual edits to ensure

accuracy. Participants were provided with their transcripts for member checking to validate the data and make any necessary modifications, following best practices for qualitative research (Brinkmann & Kvale, 2015).
The first stage of data analysis began with the data being analyzed in an exploratory manner to draw comparisons and themes from focus group conversations and interviews. Focus group responses, documented through surveys and interview transcripts, were reviewed multiple times to identify key ideas. Analysing focus group data involved a systematic approach to identifying patterns in group dynamics and collective meaning-making.

Transcripts and survey responses were coded to distinguish between group-level themes and individual insights, considering both the content of discussions and the group dynamics that shape those discussions. This process helped capture both the shared beliefs of groups and unique outlier perspectives. Notetaker surveys were cross-referenced with group transcripts to ensure accuracy and triangulate findings, enhancing data validity. Reviewing transcripts and survey data multiple times to identify recurring themes, patterns, and divergent views, ensures that the analysis captures both consensus and minority perspectives (Krueger & Casey, 2015). To analyse the interview data, a within-case analysis was conducted by examining each participant's transcript individually. The transcripts were reviewed multiple times to uncover key ideas, and a coding framework was developed, guided by themes related to mathematics education reform.

Using NVivo qualitative data analysis software, all data were coded for emerging themes such as teacher perceptions, challenges, teaching strategies, and experiences with destreamed mathematics. A codebook was developed to systematically categorise data, and sub-nodes were added as themes emerged organically throughout the analysis. The software facilitated organising data from multiple sources (focus groups transcripts and surveys, and semi-structured interviews) and allowed for the exploration of co- occurring themes across datasets.

The second stage of analysis involved examining commonalities and differences across focus groups and interview findings. The comparative process for focus groups considered how group interactions and discussions shaped collective perspectives, offering a comprehensive understanding of teacher's shared and individual experiences. This approach also helped identify themes unique to certain groups or universally resonant across all participants. By integrating focus group and interview data, the analysis produced a rich, multifaceted view of the research questions.

Results and Findings

Throughout the implementation of the grade 9 mathematics- destreamed course, teachers were found to incorporate many facets of technology within the classroom. The growth of incorporating these facets of technology can be attributed to a multitude of factors including the embedded aspects of technology within the new curriculum (e.g., coding), the accessibility and convenience of technological resources for students (e.g., online manipulatives), and the post-pandemic transitions from online and hybrid course structures (e.g., online learning management platforms). From the individual interviews, the majority of teachers mentioned technology within the context of coding, specifically reflecting on their concerns and approaches to embedding coding within their mathematics classrooms.

Coding in the Classroom

The curriculum changes of grade 9 destreamed mathematics courses were not only drastic because of the amalgamation of two previously streamed courses, but they were also drastic due to the additions to course material, like the new coding unit. As coding was a new addition to the curriculum and was not previously perceived to be connected to the subject of mathematics, it is understandable that teachers found it difficult to know when, where, and how to incorporate coding into their lessons. The new approach of spiraling was introduced along with coding in the new destreamed curriculum, as an innovative change to program planning and structuring lessons. One teacher explained their regret of taking the traditional approach to structuring coding in their classes:

> If only we could have started our coding stuff at the beginning and built that in…a month or so ago, we would have said we would have preferred to do that. It would have been much better. We think we would get better engagement for our students. Instead, now we are thinking about, 'Okay, what do we teach them, what do we not?' [We have to make] serious decisions about how much time we spend on coding versus geometry, which we have not even touched yet. (Teacher 1, interview, November 16, 2023)

For the teachers that started to implement coding during their semester teaching the grade 9 destreamed course, some expressed their fondness for the resource Google Colab. Google Colab is a platform that allows users to freely write and implement code in their browser using the widely known programming language, Python. Google Colab was described by one participant as: "It is like Google Docs for coding. It is great. I do not have to teach them how to download Python. That is the best part" (Teacher 2, interview, November 19, 2023). The same participant outlined their use of Google Colab:

> I have been using [Google] Colab because I have the [students] share their notebook with me. So, I am at least able to go and look to see if they have done anything and I have them use the text blocks to answer on the BHNmath coding resources…and then when they have to write or modify a code I have them put it in a code block, so they actually have it all in one

place… I love it. (Teacher 2, interview, November 19, 2023)

The BHNmath resource that the participant referred to is a virtual provincial secondary mathematics resource centre for parents, students, and teachers. BHNmath has been a popular resource among those teaching the grade 9 destreamed mathematics course for coding activities and lessons. Another participant stated their interest in checking out the resource: “I think there was a website provided that I found very useful. And I am planning to use it because it has a link to the BHNmath” (Teacher 3, interview, November 22, 2023).

Teacher Coding Experience

As an additional part of our study, focus group interviews were conducted to address the urgency to understand a greater range of teacher experiences and thoughts towards coding. In focus groups of three or four participants, a wide variety of responses were provided concerning their experience level with coding, comfort with teaching coding, and overall sentiments toward coding as a new part of the curriculum.

When asked about their previous coding experience, the greatest response among teachers was zero to very minimal experience. When speaking on behalf of the group, one group member stated: “Most of us have zero experience with coding” (Group 6, focus group, September 14, 2023). Another member of a different group also explained that they had “zero experience coding nor attempted pseudocodes” (Group 2, focus group, September 14, 2023). Other groups echoed the same level of experience, as another participant from another group reported: “Zero experience other than a few in-house professional development sessions led by colleagues” (Group 3, focus group, September 14, 2023).

From those who did have moderate experience with coding, many of their learning experiences were drawn from their personal schooling experience. One of the teachers described their knowledge of coding: “[I had] experience with visual basic in high school and then Python in university. It was confusing. Teacher’s college with a little bit of micro bits and then some with Lego robotics, Lego EB3” (Group 2, focus group, September 14, 2023). One participant expressed: “[I have] experience with pseudocode and python from an undergraduate degree and a coding for education [course] in pre-service training” (Group 13, focus group, September 14, 2023). Another participant also reflected on their coding experience from university, as they stated: “[I] learned C++, Python in university” (Group 7, focus group, September 14, 2023). However, for some teachers, their experience with coding was not in Python but in different programming languages. One teacher explained: “We have done some coding in university and used Maple, they are all kind of similar” and another member from the same group added: “[I] had experience in high school with HTML as well as Turing” (Group 2, focus group, September 14, 2023). Another teacher said they had “one university course in Java” (Group 10, focus group, September 14, 2023). In addition, a member from a different group indicated: “Learned Fortran in university, used Maple in Masters” (Group 7, focus group, September 14, 2023).

The other teachers who expressed moderate experience with coding were those who had familiarity with elements of block coding. One teacher attributed their coding experience to “approximately five projects that have been done using Scratch” (Group 3, focus group, September 14, 2023). A different teacher explained:

> Used Scratch a few years ago and the kids found it easy to relate because they had used it before in elementary. So, they felt more comfortable and did well with it. Tried Python but students had mixed feelings since they did not think that they were there yet. (Group 8, focus group, September 14, 2023)

Additionally, another teacher from a separate group mentioned Scratch: “[Experience with] Scratch and Python as students prefer Python because Scratch is too elementary, but Scratch is more geometry” (Group 11, focus group, September 14, 2023).

Comfort with Coding

Teachers' level of comfort with teaching is crucial, as it significantly influences students' receptiveness to new concepts in the classroom—this is particularly relevant to the introduction of coding in the destreamed curriculum. When asked about their comfort level with teaching coding in the mathematics classroom, nearly every teacher responded with very low levels of comfortability. For example, one teacher answered: “very low [comfort level]…currently low, need more knowledge before running a session with own class” (Group 3, focus group, September 14, 2023). Some of the focus groups expressed their comfort levels as ratios: “Level 3/10, Level 3/10, and Level 2.5/10” (Group 1, focus group, September 14, 2023) and “1/10 and 2/10, extremely uncomfortable” (Group 10, focus group, September 14, 2023). As a representative of their group, one teacher stated:

> On a scale from zero to five, zero being extremely uncomfortable and 5 being very comfortable, everyone agreed that it is about two. It is difficult for teachers to teach because there is a lot of troubleshooting that is required. It will be confusing if all thirty students encounter errors, how do you circulate and explain all the concepts? (Group 2, focus group, September 14, 2023)

Another participant from a different group explained: “Zero comfort level. New language that I need at least twenty hours to play around, learn, take a course, and educate myself to become confident to create activities, lessons, answer questions, plan programming, etc.” (Group 9, focus group, September

14, 2023). A different teacher described: "Very uncomfortable, I do not speak 'computer'. The experience in university was punching dots into a card to put into the computer, many, many years ago" (Group 13, focus group, September 14, 2023). A similar sentiment was felt by another teacher as they reported: "Not comfortable, worried I would not be able to help my students and teach them well" (Group 7, focus group, September 14, 2023).

Although the majority reported feelings of discomfort with teaching coding, some teachers expressed a mix of comfort levels. For example, one teacher responded on behalf of their group, stating: "Mixed feelings, some not feeling comfortable but there is the belief that teaching the pseudocode will get students some basic understanding, which is more comfortable to do. Especially since EQAO mostly does pseudocodes" (Group 8, focus group, September 14, 2023). Another teacher said: "Comfort with coding and math, but not comfortable with merging the two" (Group 7, focus group, September 14, 2023). A different participant links comfort with their previous experience They explained: "I know coding and am somewhat comfortable teaching coding in math, as I have some experience from pre-service teaching" (Group 13, focus group, September 14, 2023).

Despite reports of lower comfort levels among teachers, some teachers had hope for the improvement of their comfort with coding. One teacher detailed: "With some prior experience, there is excitement to learn and create with the students" (Group 9, focus group, September 14, 2023). Another teacher aligned with this attitude towards coding, when they expressed: "Looking forward to being more comfortable in a few years" (Group 4, focus group, September 14, 2023).

Teaching Coding: Expectations and Insights

As the reports from focus groups showed that the majority of teachers displayed a general discomfort towards coding, it is reasonable to speculate that there are many stresses, worries, and uncertainties around incorporating coding into their teaching practice. Some of these concerns with implementing coding were about having sufficient time to teach such a new concept to students. One teacher explained: "I worry that there is not enough time with the demanding curriculum" (Group 3, focus group, September 14, 2023). From another group, another teacher said that they "felt rushed because of trying to cover curriculum" (Group 10, focus group, September 14, 2023). Another teacher added to this notion, as they said: "[We] would need a lot of instruction for us and we would need to spend some time with students teaching coding basics during a time-crunched grade 9 course" (Group 4, focus group, September 14, 2023). A teacher from a separate group also stated: "Students are dealing with big gaps, and it might be difficult to teach these new concepts" (Group 1, focus group, September 14, 2023).

In contrast to the fears around teaching coding, teachers also conveyed how learning coding is valuable for students, especially for their future. While listing their thoughts around coding, one group stated: "Valuable for students to learn coding" and that they "like the idea of using coding to teach math" (Group 1, focus group, September 14, 2023). With regard to widening the job opportunities for students, one teacher detailed: "I think [coding] is important and needed nowadays. A lot of jobs are requiring it, it opens a lot of pathways" (Group 2, focus group, September 14, 2023). Another teacher from a different focus group also said: "It [coding] is very useful, students will be able to accelerate their path to careers in technology" (Group 12, focus group, September 14, 2023). In addition, a member from a different group said: "[Coding] is going to be the future" (Group 11, focus group, September 14, 2023).

Discussion

The exploration of mathematics teachers' experiences with the integration of computational thinking, particularly coding, in mathematics has shed light on the challenges and opportunities presented by this new integration. The introduction of coding as part of the Grade 9 destreamed curriculum marked a significant change, and teachers expressed varying levels of comfort and experience with this addition. The study revealed a spectrum of coding familiarity among teachers, from minimal to moderate exposure, with some relying on personal schooling experiences and others embracing block coding elements. Comfort levels with teaching coding were generally low, reflecting challenges teachers faced in assimilating this new skill into their existing pedagogical practices. This notion is also reflected in research, as teachers with perceived lower experience level have been associated with feelings of inadequacy and lower confidence when integrating technology/programming in the curriculum (Kim et al., 2020; Vinnervik, 2022). Concerns about time constraints, the demanding curriculum, and the need for extensive instruction were prevalent in this study, which align with other studies that address teachers' challenges with the lack of time and training when integrating technology in the classroom (Akram et al., 2022; Rodríguez-Muñiz et al., 2021). Despite these reservations among teachers, there was recognition for the value of coding for students' futures, emphasizing its importance in a technology-driven world and its potential to open doors to diverse career pathways. As the integration of technology in curricula continues to evolve, it is imperative to provide ongoing support and professional development opportunities for teachers to enhance their confidence and competence in integrating computational thinking into mathematics education (Olsson & Granberg, 2022). The experiences shared by these educators underscore the need for a collaborative approach, where teachers, policymakers, and educational institutions work together to navigate the coding frontier and prepare students for the challenges and opportunities of the 21st century.

References

Adler, R., & Kim, H. (2018). Enhancing future K-8 teachers' computational thinking skills through modeling and simulations. *Education and Information Technologies*, *23*(4), 1501–1514. https://doi.org/10.1007/s10639-017-9675-1

Ahern, T. C. (2009). Bridging the gap: Cognitive scaffolding to improve computer programming for middle school teachers. *Proceedings of the 39th frontiers in education conference (FIE)* (pp. 1–5). IEEE. https://doi.org/10.1109/FIE.2009.5350561

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. *Front. Psychology*. 13:920317. https://doi.org/10.3389/fpsyg.2022.920317

Benton, L., Hoyles, C., Kalas, I., & Noss, R. (2017). Bridging primary programming and mathematics: Some findings of design research in England. *Digital Experiences in Mathematics Education*, 3, 115–138. https://doi.org/10.1007/s40751-017-0028-x

Bocconi, S., Chioccariello, A., Dettori, G., Ferrari, A., & Engelhardt, K. (2016). Developing computational thinking in compulsory education: Implications for policy and practice (JRC Science for Policy Report). *European Commission*. https://doi.org/10.2791/792158

Bocconi, S., Chioccariello, A., & Earp, J. (2018). The Nordic approach to introducing computational thinking and programming in compulsory education. Nordic@BETT2018 Steering Group. https://www.itd.cnr.it/doc/CompuThinkNordic.pdf

Calder, N. (2018). Using Scratch to facilitate mathematical thinking. *Waikato Journal*, *23*(2), 43–58. https://doi.org/10. 15663/wje.v23i2.654

Chalmers, C. (2018). Robotics and computational thinking in primary school. *International Journal of Child-Computer Interaction*, *17*, 93– 100. https://doi.org/10.1016/j.ijcci.2018.06.005

Cooper, S., Dann, W., Lewis, D., Lawhead, P., Rodger, S., Schep, M., & Stalvey, R. (2011). A pre-college professional development program. In *Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer Science Education (ITiCSE '11).* (pp. 188–192). Association for Computing Machinery Digital Library. https://doi.org/10.1145/1999747.1999801

DeClerq, K. (2024). *How will kids in Ontario be taught coding in kindergarten?* CTV News Toronto. https://toronto.ctvnews.ca/how- will-kids-in-ontario-be-taught-coding-in-kindergarten-1.6742447

Gannon, S., & Buteau, C. (2018). Integration of computational thinking in Canadian provinces. In Online *Proceedings of the Computational Thinking in Mathematics Education Symposium*. http://ctmath.ca/wpcontent/uploads/2018/10/Symposium_CanadaMap_Gannon-Buteau.pdf

Grover, S., & Yadav, A. (2020). Integrating programming into other subjects. In S. Grover (Ed.), *Computer science in K-12: An A to Z handbook on teaching programming* (pp. 83–98). Edfinity.

Hackenberg, A. J., Creager, M., & Eker, A. (2021). Teaching practices for differentiating mathematics instruction for middle school students. *Mathematical Thinking and Learning*, *23*(2), 95–124. https://doi.org/10.1080/10986065.2020.1731656

Holmes, K., Hickmott, D., Prieto-Rodrigues, E., & Berger, N. (2018). Using coding to teach mathematics: Results of a pilot project. In *Proceedings of Integrated Education for Real World 5th International STEM in Education Conference* (pp. 152–158). Queensland University of Technology.

Kay, J. S., & Moss, J. G. (2012). Using robots to teach programming to K-12 teachers. In *Proceedings of Frontiers in Education Conference* (FIE) (pp. 1–6). IEEE. https://doi.org/10.1109/FIE.2012.6462375

Kim, C. M., Gleasman, C., Boz, T., Park, H., & Foutz, T. (2022) Learning to teach coding through argumentation. *Computers and Education Open*, *3*(100107), 1–17. https://doi.org/10.1016/j.caeo.2022.100107.

Krueger, R. A., & Casey, M. A. (2015). *Focus groups: A practical guide for applied research* (5th ed.). Sage Publications.

Lesh, R., & Yoon, C. (2004). Evolving communities of mind-in which development involves several interacting and simultaneously developing strands. *Mathematical Thinking and Learning*, *6*(2), 205–226. https://doi.org/10.1207/s15327833mtl0602_7

Marcelino, M. J., Pessoa, T., Vieira, C., Salvador, T., & Mendes, A. J. (2018). Learning computational thinking and Scratch at distance. *Computers in Human Behavior, 80*, 470–477. https://doi.org/10.1016/j.chb.2017.09.025

McDougall, D. E. (2004). *School Leadership Handbook for Elementary Mathematics*. Toronto: Thomson Nelson.

Miller, J. (2019). STEM education in primary years to support mathematical thinking: Using coding to identify mathematical structures and patterns. *ZDM – Mathematics Education*, *51*(6), 915–927. https://doi.org/10.1007/s11858-019-01096-y

Morgan, D. L. (1997). *Focus groups as qualitative research* (2nd ed.). Sage Publications. https://doi.org/10.4135/9781412984287

Olsson, J., & Granberg, C. (2022). Teacher-student interaction supporting students' creative mathematical reasoning during problem solving using Scratch. *Mathematical Thinking and Learning*, 1–28. https://doi.org/10.1080/10986065.2022.2105567

Ontario Ministry of Education. (2020). *Ontario curriculum and resources: Elementary mathematics*. https://www.dcp.edu.gov.on.ca/en/curriculum/elementary-mathematics

Ontario Ministry of Education. (2021). *Ontario curriculum and resources: Grade 9 mathematics.* https://www.dcp.edu.gov.on.ca/en/curriculum/secondary-mathematics/courses/mth1w

Papert, S. (2022). *Mindstorms: Children, computers, and powerful ideas*. Basic Books.

Pei, C., Weintrop, D., & Wilensky, U. (2018). Cultivating computational thinking practices and mathematical habits of mind in Lattice Land. *Mathematical Thinking and Learning, 20*(1), 75–89. https://doi.org/10.1080/10986065.2018.1403543

Rodríguez-Muñiz, L. J., Burón, D., Aguilar-González, Á., & Muñiz-Rodríguez, L. (2021). Secondary mathematics teachers' perception of their readiness for emergency remote teaching during the COVID-19 pandemic: A case study. *Education Sciences*, *11*(5), Article 5. https://doi.org/10.3390/educsci11050228

Shumway, J. F., Welch, L. E., Kozlowski, J. S., Clarke-Midura, J., & Lee, V. R. (2021). Kindergarten students' mathematics knowledge at work: the mathematics for programming robot toys. *Mathematical Thinking and Learning*, *25*(4), 380–408.

Swaid, S. I. (2015). Bringing computational thinking to STEM education. *Procedia Manufacturing*, *3*, 3657–3662. https://doi.org/10.1016/j.promfg.2015.07.761

Vinnervik, P. (2022). Implementing programming in school mathematics and technology: teachers' intrinsic and extrinsic challenges. *International Journal Technology and Design Education. 32*, 213–242. https://doi.org/10.1007/s10798-020-09602-0

Wing, J. (2008). Computational thiking and thinking about computing. *Philosophical Transactions of the Royal Society: Mathematical, Physical and Engineering Sciences*, *366*(1881), 3717–3725.

Wing, J. (2011). Research notebook: Computational thinking – What and why. *The Link Magazine*, *6*, 20–23.

Wu, L., Looi, C.K., Multisilta, J., How, M.-L., Choi, H., Hsu, T.-C., & Tuomi, P. (2020). Teacher's perceptions and readiness to teach coding skills: A comparative study between Finland, Mainland China, Singapore, Taiwan, and South Korea. *The Asia-Pacific Education Researcher*, *29*, 21–34. https://doi.org/10.1007/s40299-019-00485-x

Ye, H., Liang, B., Ng, O., & Chai, C. S. (2023). Integration of computational thinking in K-12 mathematics education: a systematic review on CT-based mathematics instruction and student learning. *International*

Journal of STEM Education, *10*(3). https://doi.org/10.1186/s40594-023-00396-w.

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Data collection and preliminary analysis are part of SSHRC Grade 9 Mathematics Research funded project. We have no conflicts of interest to disclose.

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