Chapter #3

FRENCH IMMERSION TEACHER AND STUDENT PERCEPTIONS ABOUT LEARNING SCIENCE IN A SECOND LANGUAGE

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ABSTRACT
In Ontario, students enrolled in English language schools have the option to learn academic subjects in both French and English (French Immersion). In response to requests for instructional support from French Immersion (FI) Science teachers, representatives from the Council of Ontario Directors of Education approached Laurentian University researchers to embark on a project that would contribute to building the capacity of teachers who teach Science in French in the Junior and Intermediate grades (7-10). This study utilized a mixed methods approach to investigate teacher perceptions about teaching science to second language learners, their science efficacy beliefs, and students' engagement. A total of 37 grade 7-10 FI teachers and their respective 324 students participated in the study. Findings show that most teacher participants were generally confident about their knowledge of science, felt that they taught the subject effectively, and were continually striving to engage their students in science classes. However, these teachers faced unique challenges concerning limited language proficiency among students, and lack of suitable instructional resources. Student surveys show mixed results in terms of their self-efficacy and self-regulation, those with genuine interest in science, were more likely to be confident in their ability to succeed in FI science classes.

Keywords: French immersion, science education, teacher efficacy, teacher beliefs, student engagement.

1. INTRODUCTION

In Ontario, Canada, the vision for French Immersion (FI) education is grounded in the federal linguistic duality approach, which perceives knowledge of Canada's two official languages (French and English) as an important part of Canadian history as well as a notable asset in terms of student interaction and employability on an international spectrum (Ontario Ministry of Education, 2013). In keeping with the two official languages of Canada, the education system comprises of both English language schools and French language schools. Students from English speaking homes who wish to study French can enroll in French Immersion (FI) programs offered in the English schools. These programs differ in terms of the number of subjects or hours of the day, when students can learn in French or English (Cummins & Carson, 1997). The various subjects taught in French are the same as in the regular English stream, except that they learn in a second language for the mostly English-speaking students. According to Laplante (1997), students' limited proficiency in French constrains what they can learn in various subject areas. French Immersion teachers have the task of incorporating the content objectives as well as the second language objectives in each lesson. Turnbull, Cormier, and Bourque (2012) pointed to the challenges faced by FI teachers who teach complex subjects like science and math when students' language proficiency is limited. The challenges they noted include: a) school administrator and parental expectations that their children will cover the same

subject matter as students enrolled in regular English-medium programs; and b) classroom materials that have been developed for native speakers of French that tend to be too advanced for beginning language learners. It is for this reason that fewer FI schools in Ontario offer Science and Math in French.

French Immersion teachers in Ontario Canada have highlighted similar challenges, and the current study is an effort by the Ontario Ministry of Education to respond to FI science teachers' concerns. The larger project funded by the Ontario Ministry of Education utilized research to develop resources and offered professional development workshops for middle school FI teachers. This chapter presents findings from research on teacher perceptions about FI science teaching, their science efficacy beliefs, and students' engagement in FI science. The objectives of the study were to determine: a) the relationship between teachers' science efficacy beliefs and their perceptions about teaching the subject; and b) influence of students' perceptions about science on their engagement in FI classes.

2. LITERATURE REVIEW

Numerous studies suggest that teachers' specific subject beliefs tend to be compatible with their instructional strategies (Gallagher, 1991; Rowell & Gustafson, 1993). Teachers who believe that they can influence student learning by effective teaching, and are confident in their own teaching abilities are more likely to demonstrate better performance and outcomes than teachers who have lower expectations about their ability to influence student learning (Riggs & Enocks, 1990). According to Bandura (1995; 1997) self-efficacy beliefs influence how people think, act, feel, and motivate themselves in relation to all aspects of their lives. Although researchers agree that beliefs guide teaching behaviours and practices undertaken by teachers, Riggs and Enochs (1990) proposed outcome expectancy as a second component of self-efficacy. This refers to a teacher's belief about students being able to learn science given external factors such as family background, social economic status, or school. It is widely accepted that student intrinsic motivation and self-regulatory practices can influence their engagement and achievement (Velayutham, Aldridge & Fraser, 2011). It is therefore noteworthy to mention that both teachers' own beliefs and their students' motivation towards science learning have a considerable impact on learning outcomes. However, it is also important to consider the multiple roles that other factors such as language play in learning scientific concepts. Rivard, Cormier and Turnbull (2012) reported that many teachers often note that textbooks and pedagogical resources in science tend to be too difficult for French Immersion students and that, the curriculum is too overloaded to allow for the teaching of language arts concepts (reading and writing strategies) in content instruction of scientific concepts.

Modalities of teaching various content subjects in French Immersion have been widely researched (Turnbull, Cormier & Bourque, 2011). Some researchers believe that the incorporation of more language arts practices in science will help student comprehension and learning of these concepts (Cormier & Turnbull, 2009; Lyster, 2007). Additionally, researchers have particularly conducted studies that resulted in their validating certain successful approaches to enhance student learning in FI. Rivard et al. (2012), for example, present strategies that they have developed to create rich conversational spaces in FI Science classrooms. They propose that developing reading skills is crucial in science instruction, especially in FI classrooms. The four key concepts that support their rationale are the following: the nature of science, classroom realities, the immersion context, and creating discursive spaces. Laplante (1997) suggests that some teachers have successfully

utilized thematic teaching approaches, which merge science instruction to language arts concepts in the French Immersion classroom. This would include presenting content-based science concepts while utilizing approaches related to reading and writing instruction (ex. literature circles on a current event in science, etc.). Turnbull et al. (2011) further suggest that an experimental approach that integrates literacy into science instruction and learning is beneficial to helping students in a French Immersion setting to master scientific concepts.

Several studies have addressed different facets of science teaching and learning, and presented some important considerations for teachers. A multi-national study on the Relevance of Science Education (ROSE), found that students generally agree that science and technology are important for societal growth, and mostly understand that there are benefits to learning about science (Sjeborg & Schreiner, 2010). However, they also reported that some students find it difficult to be motivated to learn science because they feel that their classes do not present enough relevant and current events to link to concepts, do not allow sufficient opportunities for debate, and teach too many theoretical scientific concepts that require rote memorization. More importantly, some students feel that they do not possess the necessary cognitive skills to grasp science concepts. The researchers suggested solutions that engage students such as experiential learning outside the classroom and helping students see science as a way to solve problems rather than learning by heart (Agence Science-Presse, 2007). Many science educators agree that engaging students with hands-on investigations is a great way to teach the subject. Teachers have reported that kids like hands-on science investigations, but they are not too interested in textbook learning (Pedretti, Bellomo, & Jagger, 2015). Researchers have come up with a long list of reasons why teachers of science do investigations with their students. For example motivating students, increasing interest and enjoyment, teaching inquiry skills, developing manipulative and fine motor skills, strengthening theoretical knowledge, teaching how scientific knowledge may be used in daily life, increasing creative thinking skills, nurturing scientific and higher order thinking skills, and developing communication skills (Hodson, 2008; Johnstone & Al-Shuaili, 2001; Reid & Shah, 2007; Wellington, 1998; Henser, 2005; Kur & Heitzmann, 2008).

3. METHODS

A mixed methods research design was utilized to gain a more in-depth understanding of the factors influencing teaching and learning of science in French Immersion classrooms in Ontario. Data were collected through telephone interviews with teachers, the Science Teaching Efficacy Belief Instrument (Riggs & Knochs, 1990), and the Student Adaptive Learning Engagement in Science Survey (Velayutham et. al., 2011). Both instruments are based on a 1-5 Likert scale rating (where 1= strongly disagree and 5= strongly agree). The participant recruitment process involved sending invitation letters to teachers in School Boards that offer French Immersion Science in grades 7-10 across Ontario. A total of 37 teachers were recruited, 30 grade 7-8 teachers, and 7 grade 9-10 teachers. The researchers scheduled a 20-25 minute telephone interview with each teacher at a time that was convenient for them. The interview questions gathered teacher biographical information as well as their perceptions about FI science teaching challenges, teaching strategies, and their own science knowledge. All the interviews were audio-recorded. The Teacher Efficacy Belief Instrument was administered in person when teachers attended professional development workshops that were offered as part of the project. The researchers then

visited the classrooms of 10 volunteer teacher participants to administer the Student Adaptive Learning Engagement in Science Survey. A total of 132 students completed the survey. Qualitative data analysis involved transcribing the telephone interviews verbatim. The researchers and research assistants read and re-read the transcripts to identify emerging themes. Quantitative data were analyzed using SPSS software to determine the variability in responses as well as to see relationships among the themes. A triangulation of the quantitative and qualitative data enabled the researchers to develop a richer understanding of the factors that may directly influence FI science teaching and learning.

4. FINDINGS

4.1. Science teacher efficacy beliefs

Findings from the Science Teacher Efficacy Beliefs Instrument (STEBI) show that the majority of participants generally felt confident about their own understanding of science (Table 1). However, a significant number of teachers did not feel confident about the abilities of their FI learners to design their own investigations. Teacher responses to most of the items on the STEBI had a low standard deviation (SD<1.0), showing that in most cases the teachers generally shared similar beliefs about their FI science teaching practices. There were few questions that had outliers, showing diverse views as indicated by higher standard deviations (SD>1.0). Table 1 below highlights the type of questions with outliers, these were grouped into 3 categoties of teacher beliefs.

Table 1.
Teacher beliefs about their science knowledge and ability to affect student learning.

Teacher Beliefs	Questions (n=37)	Mean	SD
Teacher confidence about their own knowledge and teaching capability	*Question 5* - I know the steps necessary to teach science concepts effectively	3.59	1.05
	Question 12 - I understand science concepts well enough to be effective in teaching elementary science	4.0	1.07
Teacher beliefs about their Impact on student learning	*Question 14* - The teacher is generally responsible for the achievement of students in science	3.05	1.05
Teacher beliefs about using science inquiry strategies	*Question 26* - When teaching science I let students design their own investigations and gather the evidence	3.41	1.05
	Question 30 - When teaching Science I require my students to communicate and justify their explanations to the class	3.96	1.09

Responses to the questions shown in table 1 indicate that, although the majority of teachers show confidence about their science knowledge (mean of 4.0 and SD>1), there are a few teachers on the margins who either strongly believe in their knowledge and practice, or lack confidence in their own knowledge and practice. Similarly, although a fair number of teachers were confident about their abilities to impact student learning (Mean 3.05 and SD>1), there are a few teachers on the margins who either feel very confident in their teaching effectiveness, or feel that they are not able to effectively impact their students'

learning. Whereas some teachers felt confident about their students' abilities to design their own experiments, a few teachers either strongly believed, or did not believe in their students' inquiry abilities.

4.2. Teacher perceptions about FI science teaching

Data from teacher interviews show similar trends to the quantitative results, and it helped to provide an in-depth understanding of the trends observed. When asked if they feel they have enough knowledge to teach FI Science, most of the teachers said that they had enough knowledge. However, some teachers mentioned that they felt more comfortable teaching only some of the units, and that they needed support with resources that would help them to teach well, as highlighted by one of the teachers; *"Yes and no. I think there are certain strands that we're more comfortable with…I find that I do it, but I would like more resources…"* Most grade 9 and 10 teachers were generally confident about their level of science knowledge and ability to teach the subject in general, but they felt that there were some topics where their knowledge was shaky. On the other hand, a few grade 7 and 8 teachers did not feel that they had enough knowledge of the subject, because either they did not major in science or they were teaching it for the first time as shown in the following quotation from a grade 8 teacher:

> *"Um...I could definitely use a lot of work. Again, one of the questions on your survey was, have I taken any courses...post-secondary courses...no I have not…Basically, I'm just basing it off of like...my main research and through the Pearson textbook."*

Notably, most of the teachers interviewed reported that a common challenge in teaching FI science to students who typically do not speak French as a first language is that they spend more time ensuring that students understand the scientific vocabulary, which leaves them limited opportunities for inquiry-based teaching. Findings show that all the teachers generally agreed that some of their students had limited French vocabulary, which made it difficult for them to comprehend the concepts. The following quotation captures the teachers' concerns:

> *"Though, the concepts are hard enough on their own, students don't have the basic vocabulary they need to understand it, so they have two challenges at the same time, so trying to get them to digest all these new concepts along with a whole bunch of new words for them. So they may have already heard the English term before, just out in the world, so they have a little bit of an understanding of what the English word means, but suddenly when you put it in French, they have an extra challenge."*

Teachers also noted that there were varying levels of student's abilities throughout their classrooms. They felt that some of their students would be better off in the English programs where the resources to support them are available:

> *"I do have students that are in there because mom/dad wants them to be in there and they don't understand a bit of French. And then I have uhm, students that are there from the French world, they had instructions in French from kindergarten until grade 6, and then they switch into our board, so varying levels really, some of them kids are getting it, and then some kids are just, like it gets over their heads."*

Some of the teachers interviewed had the dilemma of whether to focus on students' mastery of the French vocabulary or the understanding of science concepts regardless of the language used. Lack of teaching resources that are suitable for the students' level of French comprehension exacerbated these challenges as noted by one 8th grade teacher:

> *"…finding resources that are at the student's level for French Immersion is difficult because a lot of the times the textbooks are written for Francophone students, so if they're doing any kind of reading I usually have to do it as a class and then really break down the vocabulary, so some of the time finding resources at their level is challenging."*

The majority of teachers mentioned that they use different strategies to ensure that students understood the concepts, for example, using English videos that help to explain the concepts or using both English and French when necessary as shown in the following quotation:

> *"I, sadly have to use English resources to just solidify, like the stuff to make sure that they understand it…A lot of visuals, lots of, and lots of hands on."*

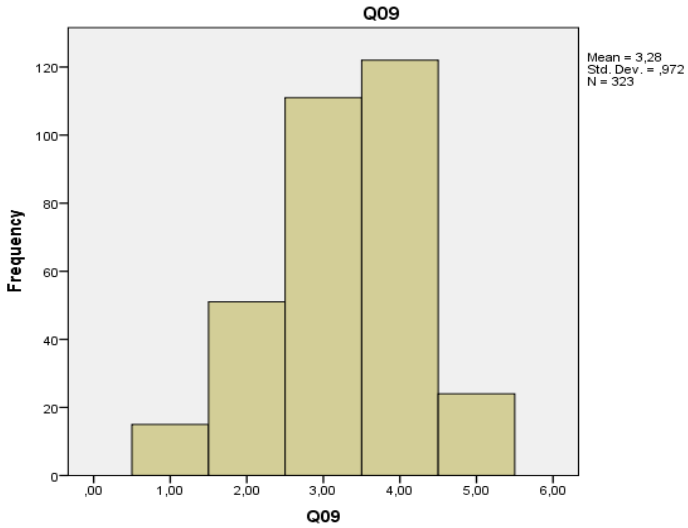
Most grade 9 and 10 teachers also mentioned using hands-on investigations, as well as practical and visual ways to help students understand the French materials, as illustrated in the following quotation:

> *"Um, so I do always try to have some kind of visual, especially with the French students I find they need the visual with it. I know there is visual learners in other areas as well, but I find it particularly useful in French so they normally have their graphic organizer or a list of vocabulary or, uh, even something up on our projector that they can refer back to throughout a lesson. In the early stages, we do a lot of working together and then in smaller groups."*

4.3. Student adaptive engagement in science

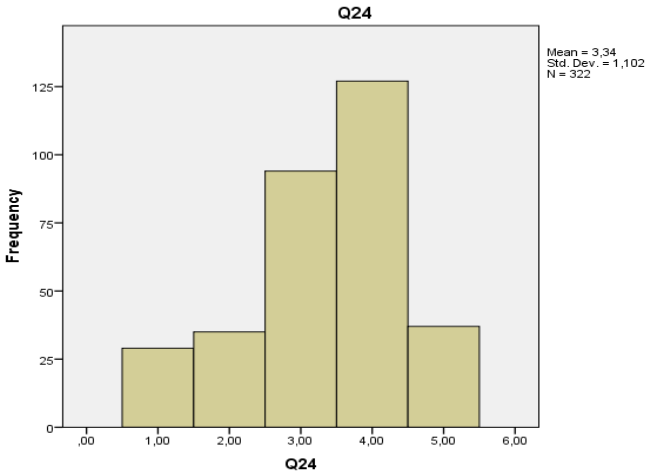
Findings from the students' adaptive engagement questionnaire show that students in this study generally have positive attitudes towards science, and they realise that it is important to learn the subject. Although students' responses show, beliefs that, given time and effort, they could succeed; the data also show that they lack confidence about their knowledge and ability to master scientific knowledge and skills. It is important to note that data from students in grades 9 and 10 has lower standard deviation than that of students in grades 7-8 (where there are more outliers). Responses to the question about mastering science skills showed lower averages and high deviance, which indicates that contrary to their perceptions of the importance of the subject; some students do not have a strong inclination to learning it. Figure 1 below shows the distribution of student responses to questions about the relevance of science in their daily life, which had a mean value of 3.28 and SD 0.97 (N=322). There were outliers showing that there are a few students who consider the subject very relevant and a few who do not.

Figure 1.
Student perceptions about the relevance of science in their daily lives.



Responses to questions about student self-efficacy show that most students may not appear to have confidence in their ability to perform well in science class. Figure 2 below shows the distribution of student responses to the question about how good they are at the subject. A mean of 3.34 & SD 1.1 (N= 322) shows that the majority of students do not believe in their abilities in the subject, and only less than half of the students believe in their learning abilities.

Figure 2.
Student self-efficacy, confidence and attitudes towards science.



5. DISCUSSION

Findings from this study indicate that the teachers generally believe that they have the science knowledge needed to teach, and that they can teach the subject effectively. On the other hand, these teachers were concerned about their ability to influence students' learning in FI science. They strongly expressed the need for more support and resources in order to meet the needs of students learning science in a second language. They also expressed their concern about some of their students who were having difficulty learning science due to limited French proficiency. Although previous findings on science teacher beliefs show that teachers' specific subject beliefs tend to be compatible with their instructional strategies (Bourgoin, 2016; Gallagher, 1991; Rowell & Gustafson, 1993), findings from the current study are contrary. The difference in findings is due to the study context. Whereas previous studies focused on science classrooms for first language learners, the second language context in this study makes it difficult for students to learn complex concepts regardless of teacher beliefs (Davis, Ballinger & Sarkar, 2019; Vandergrift & Baker, 2018). The findings are in agreement with Turnbull et al. (2012) who pointed to the challenges faced by FI teachers who teach complex subjects like science and math when students' language proficiency is limited. From interviews with teachers, it was clear that there is a difference in the level of French language proficiency among students, with some students struggling to learn science in a second language.

Secondly, most teachers strongly felt the impact that lack of teaching resources such as textbooks and other online sources specifically designed for second language learners had on their practice. This finding is in agreement with the earlier report by Rivard et al. (2012) who highlighted the challenges faced by FI science teachers due to lack of resources that meet the needs of French Immersion students. Findings from this study are also consistent with earlier studies that have reported on the overloaded FI science curriculum that hampers the ability of teachers to engage students in inquiry investigations. Teachers have reported that they spend more time ensuring that students understand the science vocabulary in French. It is therefore clear from the findings that external factors influence teachers' practice, and this likely leads to "teachers feeling they have no control" (Riggs & Enochs, 1990, p. 633). These challenges can help to explain some of the teachers' lack of confidence in their abilities to influence student learning in FI science. Since FI students are required to become fluent in the French language as well as achieve the curriculum expectations, teachers have the dilemma of whether to focus on assessing one or the other. Some teachers felt that limited French language proficiency hampered the abilities of some students to communicate their understanding of science concepts. Some studies support this assumption, indicating that literacy and content skills develop interdependently across languages (Archambault, Mercer, Cheng & Saqui, 2018). The teachers therefore felt that there is need for assessment requirements in FI to be more flexible in order to enable them to assess understanding of concepts even when a student has limited language proficiency.

Most teachers reported that they were trying to use different teaching strategies to help their students who have limited French language proficiency, and others reported using English langauge resources due to limited French resources that are at the level of their students. The teachers also reported that they found themselves in a situation where they have to develop their own resources in order to accommodate the language proficiency level of their students. Similarly, teachers' responses varied in terms of their beliefs about using inquiry strategies, with almost half the teachers indicating that they would not let students design their own experiments. Most teachers mentioned that they did not have enough time to engage students in hands-on investigations since they spend more time

teaching vocabulary. These challenges clearly show the reasons why some teachers felt that students who were struggling to express themselves in French would not be able to design their own inquiry investigations.

In addition to lack of resources, and lack of proficiency in the French language among some students, other factors such as student's science background, and low motivation could be contributing to the challenges faced by the FI teachers. Data from the students' adaptive engagement in science questionnaire show that most students lack confidence about their science knowledge and ability to master scientific knowledge and skills. Similarly, a wide distribution in terms of students' beliefs about the relevance of science shows that the majority of students generally think that the subject is relevant in their daily lives. This wide distribution in responses may be due to differences in French language proficiency among students. Students may find it difficult to express their understanding in a second language, which could lead to lack of confidence in their ability to perform well. Similarly, lack of language proficiency could also inhibit comprehensive understanding of the content and its application to their lives. The differences in responses among students may also be due to the difference among performing and underperforming students. Although there were no significant differences among students at different grade levels for most questions, the question referring to self-regulation had more outliers among grade 7 and 8 students compared to those in grades 9 and 10. This is because students who continue in the FI stream in high school are generally more proficient in the French language; hence, they are willing to work hard when facing difficult problems.

6. CONCLUSION

This study investigated FI teacher perceptions about teaching science to second language learners, their beliefs about science teaching efficacy, as well as students' adaptive learning engagement. A total of 37 grade 7-10 FI teachers and their respective 324 students from across Ontario, Canada, participated in the project. Data were collected through telephone interviews, completing *the Science Teaching Efficacy Belief Survey* (for teachers) and the *Student Adaptive Learning Engagement in Science Survey* (for students). Findings from the study show that the teachers generally believe that they have the science knowledge needed to teach, and that they can teach effectively. Student survey results show a wide distribution of responses in terms of confidence in their knowledge and ability to master scientific knowledge and skills, indicating that there are outliers with some students who have good understanding and a few who are struggling. The study findings also show that FI teachers face several challenges including, limited French language proficiency among their students and lack of instructional resources suitable for French second language learners. Teachers have to find suitable resources, translate resources as well as design their own resources in order to accommodate their learners; and c) lack of assessment policies that are specific for second language learners. In order to address the challenges faced by FI teachers there is need to provide FI science resources that are at the reading level of French second language learners. There is also need for flexibility in terms of curriculum coverage and assessment for students learning science in French in order to enable teachers to accommodate all second language learners who may have limited French language proficiency. This study clearly shows that other factors should be taken into consideration when investigating science teacher efficacy and beliefs in FI or any second language learning context.

The implications of the study findings for FI teachers and for educators in general are that where teachers have strong beliefs and confidence in their knowledge of the subject being taught, they are likely more apt to create a better learning environment for their students. However, in order to ensure optimal performance by these teachers, resources that are at the level of the language proficiency of the students such as textbooks, videos, inquiry activities, and worksheets must be provided. As such, teachers who lack confidence in their knowledge should continuously strive to build and update their content knowledge in order to improve their students' learning. There is need to provide professional development initiatives and supports especially for primary teachers who may not have specialization in the content area. In turn, where students lack confidence in their scientific abilities, they are less likely to be engaged in their learning. This finding underscores the importance of providing the necessary resources and supports that will enable teachers to use inquiry-based activities in order to motivate learners, promote understanding, and help them to appreciate the importance of science in their daily lives. Moreover, participants in this study appeared to concur that science assessment and evaluation should focus on understanding of concepts, and that language abilities should be assessed in the language class. This would provide a clearer picture of the students' true performance levels in both subjects, independent of the other. In sum, there appears to be a societal stigma that transcends the walls of the classroom, where science is sometimes perceived as an elite subject in which strong students are expected to succeed (Agence Science-Presse, 2007). One way to commit to spreading the message that everyone can be successful in science, regardless of academic abilities or language of instruction is to provide the necessary resources and supports to teachers of second language learners.

REFERENCES

Agence Science-Presse. (2007). *Que ceux qui aiment les sciences lèvent la main* [May those who like science raise their hand]. Retrieved from: https://www.sciencepresse.qc.ca/actualite/2007/12/31/aiment-sciences-levent-main

Archambault, C. Mercer, S., Cheng, M. & Saqui, S. (2018). Lire en Français [Reading in French]: Cross-Linguistic Effects of Reading Fluency Interventions in French Immersion Programs. *Canadian Journal of School Psychology, 34(2)*, 113-132.

Bandura, A. (Ed). (1995). *Self-efficacy in changing societies*. Cambridge, UK: Cambridge University Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY, US: W H Freeman/Times Books/Henry Holt & Co.

Bourgoin, R. (2016). French Immersion "So Why Would You do Something Like That to a Child? Issues of Advocacy, Accessibility, and Inclusion. *International Journal of Bias, Identity and Diversities in Education, 1*(1), 42-58.

Cormier, M, & Turnbull, M. (2009). Une approche littératiée: Apprendre les sciences et la langue en immersion tardive [A litteracied approach: Learning science and language in late immersion]. *Revue canadienne des langues vivantes*, 65, 817-840.

Cummins, J, & Carson, D. (Eds.). (1997*). Encyclopedia of Language and Education. Volume 5. Bilingual Education* (26/-269). The Netherlands: Kluwer Academic Press.

Davis, S., Ballinger, S., & Sarkar, M. (2019). The Suitability of French Immersion for Allophone Students in Saskatchewan: Exploring Diverse Perspectives on Language Learning and Inclusion. *Canadian Journal of Applied Linguistic, 22*(2), 27-63.

Gallagher, J. J. (1991). Prospective and practising secondary school science teachers' knowledge and beliefs about the philosophy of science. *Science Education, 75*(1), 121-133.

Henser, D. (2005). Inquiry, science workshop style. *Science and Children*. 32-36.

Hodson, D. (2008). *Towards scientific inquiry: A teachers' guide to the history, philosophy and sociology of science.* Rotterdam: Sense Publishers.

Johnstone, A. H, & Al-Shuaili, A. (2001). Learning in the laboratory: Some thoughts from the literature. *University Chemistry Education*, *5*(2), 42-51.

Kur, J, & Heitzmann, M. (2008). Attracting student wondering. *Science and Children*. 28-32.

Laplante, B. (1997). Teachers' beliefs and instructional Strategies in science: Pushing analysis further. *Science Education, 81*(3) 277-294.

Lyster, R. (2007). *Learning and teaching languages through content: A counterbalanced approach.* Netherlands: John Benjamins Publishing Company.

Ontario Ministry of Education. (2013). *A framework for French as a second language in Ontario schools*. Toronto, ON: Queen's Printer for Ontario.

Pedretti, E, Bellomo, K, & Jagger, S. (2015). *Explorations in elementary school science: Practice and theory K8.* Toronto: Pearson.

Reid, N. & Shah, I. (2007). The role of laboratory work in university chemistry. *Chemistry education research and practice, 8*(2), 172-185.

Riggs, I. & Enochs, L. (1990). Towards the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74(6)*, 625-637.

Rivard, L, Cormier, M, & Turnbull, M. (2012). Reading strategies in French Immersion science classes: Preparing our students for tomorrow. *Canadian Journal of Science, Mathematics and Technology Education, 12*(1), 86-102.

Rowell, P. M, & Gustafson, B. J. (1993). Beginning to teach: Science in the elementary classroom. *Alberta Science Educational Journal, 26*, 4-10.

Sjeborg, S, & Schreiner, C. (2010). *The ROSE project: An overview and key findings.* University of Ohio. Retrieved from: https://roseproject.no/network/countries/norway/eng/nor-Sjoberg-Schreiner-overview-2010.pdf

Turnbull, M, Cormier, M, & Bourque, J. (2011). The first language in Science class: A quasi-experimental study in late French Immersion. *The Modern Language Journal, 95*, 182-198.

Turnbull, M, Cormier, M, & Bourque, J. (2012). The first language in science class: A quasi-experimental study in late French immersion. *The Modern Language Journal*, *95*, Supplementary issue (2011). doi: 10.1111/j.1540-4781.01275

Vandergrift, L. & Baker, S. (2018). Learner Variables Important for Success in L2 Listening Comprehension in French Immersion Classrooms. *The Canadian Modern Language Review, 74(1)*, 79-100.

Velayutham, S, Aldridge, J, & Fraser, B. (2011). Development and validation of an instrument to measure students' motivation and self-regulation in science learning. *International Journal of Science Education, 33*(15), 2159-2179.

Wellington, J. (1998). Practical work in science: Time for a re-appraisal. In J. Wellington (Ed.), *Practical work in school science. Which way now?* (pp. 3-15). New York: Routledge.

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