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Mathematics Anxiety, Resiliency, and Chemistry Performance of Grade 9 Students

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Abstract. While Mathematics is a necessary component of Science, many students enter scientific courses with minimal arithmetic skills. This descriptive-correlational study examined the relationship between Grade 9 students' Mathematics anxiety and resiliency to their academic achievement in Chemistry. Data was collected from the 302 participants drawn from the total population of 1,394. A three-part, fully adopted questionnaire was used. Descriptive scores were analyzed and interpreted using mean and standard deviation. To test for significant differences in the aspects of the dependent variables, Mann-Whitney U was used, and Spearman's rho correlation was used to test for significant relationships. Results of the study revealed that the level of Mathematics anxiety of the Grade 9 students was on the "average". On the other hand, the level of Mathematics resiliency of the Grade 9 students was "high". The study also reflected that Grade 9 students were proficient in Chemistry. Mathematics anxiety and resiliency do not correlate with Grade 9 students' academic achievement in Chemistry. Anxiety and resiliency of Grade 9 students towards Mathematics do not affect their ability to acquire knowledge in Chemistry. Student experience of Mathematics anxiety is not closely related to their academic achievements. It is recommended that schools provide opportunities for students to cultivate more positive attitudes toward Mathematics.

Keywords. Mathematics Anxiety and Resilience, Chemistry Performance, Descriptive-correlational research, Central Philippines

1. Introduction

Mathematics, one of the primary academic disciplines worldwide, is essential to many of our most common daily activities and routines, such as shopping, banking, cooking, and home repair [1]. Moreover, in today's increasingly technologically dependent culture, a rising number of employments require mathematics and Science expertise [2]. The incorporation of Mathematics as a fundamental topic throughout the educational process aids in developing students' critical-thinking abilities [3]. Studying and comprehending mathematical concepts can enhance students' ability to reason analytically, critically, and abstractly.

While Mathematics is a necessary component of Science, many students enter scientific courses with minimal arithmetic skills, like Chemistry students who need to familiarize themselves with the mathematical concept of a logarithm. Hence, the students may

spend weeks attempting to comprehend a scientific concept, and a student learning how to perform scientific activities may be anxious to hear that to achieve the objectives of the activities, they will be solving mathematical equations [4]. Students who need help comprehending introductory algebra may be unable to solve for mass in the equation $F = ma$ [5].

Mathematics teaches students problem-solving skills, how to connect seemingly unrelated events, and how to think [3]. Along with learning about numbers and mathematical operations, Mathematics allows students to develop their calculating abilities [6]. Mathematics, among other things, aids in the comprehension and mastery of other subjects in the Sciences and arts. When it comes to teaching children math, educators must be aware of the obstacles they will face, as it is common for children to have unfavorable attitudes toward math when they are younger [7].

Fear of the subject is one of the most frequent reasons students fail to develop competence and mastery in Mathematics [8]. Math anxiety is an uncomfortable condition that can hurt students because of the frequent presentation of fear about Mathematics problems in the classroom [9]. Students at all educational levels experience math-related anxiety, which worsens as the school year progresses [7]. Students' Mathematics anxiety may be an excellent predictor of future academic achievement [10]. Students concerned about math scored poorly on exams during their studies [11].

On the other hand, students' affective ability to deal with and overcome obstacles and negative situations during the learning process, especially in Mathematics, transforming those negative situations into situations that support them, is associated with resilience. Resilient students achieve better learning outcomes than expected [12].

The practical concept of "Mathematical resilience" describes the positive characteristics that allow students to engage with, learn, and apply mathematics inside and outside the classroom [13]. They proposed four correlated factors that contribute to mathematical resilience: the value, the struggle, the growth, and the resilience, a mindset that allows one to respond positively in the face of adversity or difficulty in Mathematics.

After establishing Mathematics anxiety and resiliency, this study investigated their relationship to learning Science. Science and Mathematics are frequently associated with one another, and scientists indeed rely on one another — the pages of any modern biology, Chemistry, Geology, or even Psychology are strewn with calculations, statistics, graphs, and mathematical models, as are the pages of any scientific journal [14]. Calculating the measurements of things and their features and demonstrating the relationship between distinct functions and qualities are accomplished by applying Mathematics in Physical Science [15].

With the pandemic, schools within the respondents' area offered classes for all subjects, including Chemistry. While students already had hard times in Chemistry classes, it was heightened by the lack of face-to-face discussions where they would only rely on the modules. These changes in the educational system may go beyond the pandemic. With problems like classroom shortages, some schools may still use blended learning instead of in-person classes. Learning may still linger and may be an option for some learners in situations of disadvantage.

With these facts, the researchers were prompted to investigate the Mathematics anxiety and Mathematics Resiliency of Grade 9 students and how these relate to their academic achievement in Chemistry. This study may open doors to new teaching strategies and interventions to achieve high performance in Chemistry and other Sciences.

2. Framework

This study theorized that Mathematics anxiety and resiliency could affect students' performance in Science. This research is anchored on Albert Bandura's Social Cognitive Theory [16]. Mastering knowledge and competence usually necessitate a sustained effort in the face of challenges and obstacles because social reality is inherently tricky. Given Mathematics, some students may have unpleasant but unavoidable experiences during the learning process, and students have experienced failure and difficulties during the learning process. Although the event is unavoidable, the negative consequences can be reduced or eliminated by developing resilient learning abilities [12].

Approximately one-third of 15-year-old students experienced Mathematics anxiety when asked to complete mathematical problems, according to the 2018 Programme for International Student Assessment (PISA) [17]. However, because the data provided by PISA were based on self-reported sentiments of Mathematics anxiety rather than actual assessments of Mathematics anxiety, it is not known what the actual percentage of students who have Mathematics anxiety is.

Mathematics is critical to STEM education because most fields require mathematical reasoning to solve problems [18]. Math anxiety is often seen as a potential hindrance to success in the STEM fields. According to current understanding, Mathematics anxiety is directly linked to avoidance of and underperformance in STEM-related fields [19].

Social cognitive theory is a widely used theory used to educate students about Mathematics anxiety and better explain the relationship between Mathematics anxiety, Mathematics performance, and Mathematics achievement [20]. This theory claims that Mathematics anxiety influences an individual's cognitive abilities and any physiological changes that may arise due to Mathematics anxiety taking root.

This framework can be applied in this study that Mathematics anxiety can cause poor cognitive performance. Therefore, Mathematics anxiety triggered by mathematical activities, which are also present in Science topics, can cause poor performance in Chemistry since in Chemistry, students have to balance a chemical reaction's equation, do necessary mathematical calculations, and use dimensional analysis to acquire information about reactions ranging from the mass of chemicals reacted to the concentration of a chemical in a solution. Additionally, arithmetic determines the amount of energy in reactions, the gas compression, the grams required to add to a solution to attain the correct concentration, and the quantities of reactants required to generate the desired product.

Maloney and Beilock [21] used cognitive theory to study and discover the association between a student's Mathematics anxiety and subsequent low academic performance. While previous research suggested that Mathematics anxiety was caused by the individual being less skilled, possibly because of a missed opportunity to learn Mathematics, and possibly less prepared and practiced in Mathematics [22]. It was proposed that the link between Mathematics anxiety and performance could be explained by less available working memory due to other tasks [21].

3. Methodology

This research utilized the descriptive-correlational research design to analyze and discuss the current situation. Descriptive research is a method used to describe actual phenomena as precisely as feasible [23]. Descriptive research examines the characteristics of a population, identifies problems within a unit, organization, or population, or examines variations in traits or behaviors among organizations or even nations [24].

This research was carried out in one large secondary school in a component city in the central Philippines. At the time of the study, the school has 324 teachers catering to 6345 students.

The population in this study was 1,426 9th Graders, where 302 were randomly drawn out as samples.

A three-part, fully adopted questionnaire was used to collect data for this study. The first section sought information on the respondents' characteristics. The questionnaire, an adaptation of the Modern and Refined Shortened-Mathematics Anxiety Rating Scale (s-MARS), consists of 15 items that assessed the degree to which participants experienced anxiety in various situations on a scale of 1 to 5 to generate quantitative results. The third section is an adapted questionnaire to measure the Mathematical Resilience Scale adapted from Kookan et al. [25], created from the concept of 'mathematical resilience' [13]. To determine the students' performance in Chemistry, their grades for Chemistry were used during the 2nd quarter of the school year 2021-2022. To measure the reliability of the instrument used in this study, it was pilot tested on thirty (30) Grade 9 students who were not included in the sample.-Cronbach's Alpha was used to assess the study's internal consistency with results of 0.77 for the Mathematics Anxiety Scale and 0.75 for the Mathematics Resiliency Scale. Both show an acceptable level of reliability.

Permission to conduct the study was sought from the administrators of the school. The researcher personally sent out the questionnaires to the respondents while observing proper pandemic protocols. When retrieving questionnaires, the same procedure was used. This allowed the researcher to collect the participants' responses while ensuring that the questionnaires were retrieved as soon as possible.

Mean and standard deviation were used to analyze descriptive data. Shapiro-Wilk test of normality shows deviation from normality. Thus, non-parametric Mann-Whitney U and Spearman's rho were utilized for inferential analysis.

The researchers addressed the general principles of respect for persons, beneficence, and justice to ensure the ethical soundness of the study. These principles include social value, informed consent, the vulnerability of the research participants, risk and benefits, privacy and confidentiality, justice, transparency, adequacy of facilities, and community involvement.

4. Results and Discussion

Level of Mathematics Anxiety

Table 1 shows the level of Mathematics anxiety of Grade 9 students when taken as a whole and grouped according to sex. This result shows that the Grade 9 students have an average level of anxiety towards Mathematics ($\bar{x}=3.07$, $SD=0.71$) when taken as a whole. This also indicates that male respondents are less anxious about mathematics than female respondents.

Table 1. Level of Mathematics anxiety of Grade 9 modular students when taken as a whole and grouped according to sex

Variable	\bar{x}	SD	Interpretation
Sex			
Male	3.03	0.75	Average
Female	3.11	0.68	Average
As a Whole	3.07	0.71	Average

Gender is one of the elements that has gotten the most attention regarding math anxiety. According to studies, in nations where both genders receive equal education, males and females have little or no difference in fundamental Mathematics skills [26]. Females tend to rank themselves lower and report a more significant concern about Mathematics, although these differences are not substantial [27].

This result of the current study implies that there are factors that may affect the level of anxiety towards Mathematics which is different between males and females. Females tend to exhibit higher levels of trait anxiety [28] and a higher prevalence of clinical anxiety disorders [29]. Even in domains where their performance is higher than that of males, such as foreign language study, they are more concerned than males [30].

Males are also more self-assured and rank higher in various domains than girls [31]. As a result, it is not surprising that this applies to Mathematics and that, given the links between anxiety and self-rating, it could lead to gender differences in mathematics anxiety.

Another possible reason for females' higher math anxiety than males is stereotype threat [21]. When people fear confirming a negative stereotype about their group, a stereotype threat emerges. This usually refers to females being reminded of the stereotype that males are better at mathematics than females, but it can also apply to other stereotypes.

While the result of this study shows that Grade 9 students' mathematics anxiety is average, it is worth noting that students must overcome Mathematics anxiety. Individuals suffering from mathematics anxiety have low confidence in their ability to do mathematics and tend to take the bare minimum of compulsory mathematics courses, severely limiting their job opportunities [32]. Fortunately, several measures can function as barriers or prevent arithmetic anxiety. When people become self-aware of math anxiety and its repercussions, their ability to overcome it improves [33]. On the other hand, activity-based learning and online/distance learning may minimize the fear of appearing stupid in front of peers [34]. Another method for reducing math anxiety and increasing confidence is to use untimed/unassessed (low-stakes) tests. Math anxiety can be reduced by applying mathematics and statistics to real-life applications rather than pure mathematics [18].

Level of Mathematics Resilience

Table 2 shows the level of Mathematics resiliency of Grade 9 students when taken as a whole and grouped according to sex. Grade 9 students, based on the results of this study, tend to be resilient to Mathematics (\bar{x} =3.83, SD=0.62). Male respondents (\bar{x} =3.88, SD=0.62) are even more resilient than female respondents (\bar{x} =3.77, SD=0.63).

Table 2. Level of mathematics Resiliency of Grade 9 modular students when taken as a whole and grouped according to sex

Variable	\bar{x}	SD	Interpretation
Sex			
Male	3.88	0.62	High
Female	3.77	0.63	High
As a Whole	3.83	0.62	High

Resilience, defined as a person's ability to overcome or adapt to adversity, has received much attention in recent years [35] and is especially crucial in the present COVID-19 pandemic. In educational research, students are academically resilient if they perform significantly better than their beginning circumstances suggest [36].

Resilience is linked to academic achievement and other aspects of life [37]. Resilient students have more opportunities to reach their full potential, are more likely to progress socially, and are less likely to fall into poverty [38]. Supporting and building intellectual resilience is one strategy to increase equity in educational systems [39]. However, academic failure and social adversity have been linked to resilience.

Mathematics anxiety has long been a concern in teaching and learning, and it relates to students' dread, tension, and trepidation during arithmetic exercises [40]. Students with a high level of mathematics resilience show more remarkable perseverance in learning mathematics despite adversity. On the other hand, students' low resilience would diminish persistence in the face of adversity.

Most Grade 9 students believe hard work and determination can improve and develop their intelligence and ability to learn the subject. People with growth mindsets do not believe they are unique individuals born with the ability to win. They are diligent workers who have learned to maintain their attention under duress. People with a growth mindset seek out and thrive on challenges [40].

Academic Performance in Chemistry

Table 3. Level of Performance in Chemistry of Grade 9 modular students when taken as a whole and grouped according to sex

Variable	\bar{x}	SD	Interpretation
Sex			
Male	85.97	4.07	Proficient
Female	85.41	3.53	Proficient

Table 3 illustrates the level of Performance in Chemistry of Grade 9 students when taken as a whole and grouped according to sex. The results of the collection and statistical treatment of the data of the Grade 9 students' academic achievement in Chemistry reveal that the respondents are proficient in Science ($\bar{x}=3.07$, $SD=0.71$). Female respondents ($\bar{x}=3.11$, $SD=0.68$) were more proficient than male respondents ($\bar{x}=3.03$, $SD=0.75$).

This result further reveals that the students exhibit a high performance in Chemistry subject and have an excellent understanding of the topics in Chemistry.

In light of the findings of this study, and comparison, to previous studies on scientific proficiency in the Philippines, the Philippines received an average Scientific Literacy score of

357 points in PISA 2018, significantly lower than the OECD average of 489 points [41]. Filipino students' average score is within Proficiency Level 1a. As a result, a typical Filipino 15-year-old student can detect or identify scientific occurrences using fundamental Science knowledge. They can undertake structured scientific inquiries with at most two variables with further instruction. In comparison, a typical 15-year-old OECD student at Proficiency Level 3 can generate explanations of recognizable occurrences using relatively detailed content knowledge.

As female students were found to be more proficient than males, this is supported by the PISA 2018 results, which state that female students in the Philippines had an average Scientific Literacy score of 359 points, which was higher than male students but not substantially different (355 points). Proficiency Level 1a was assigned to both genders' mean scores. Meanwhile, male and female students in the OECD scored at Proficiency Level 3 on the Scientific Literacy measure.

Differences in the Level of Mathematics Anxiety

Another key goal of this research is to see if there is a significant difference in the level of Mathematics anxiety among Grade 9 students when they are divided into groups and compared by sex. The results demonstrate no significant difference in Mathematics anxiety between male ($\bar{x}=3.03$, $SD=0.75$) and female ($\bar{x}=3.11$, $SD=0.68$) Grade 9 students when grouped by sex. These findings suggest that the level of Mathematics anxiety among Grade 9 students is unaffected by gender. It also implies that sex has no bearing on the level of Mathematics anxiety among Grade 9 students. As a result, the null hypothesis is not rejected.

Table 4. Significant difference in the level of mathematics anxiety of Grade 9 students when grouped according to sex

Variable	\bar{x}	SD	p – value	Significance at $\alpha= 0.05$	Decision
Sex					
Male	3.03	0.75	0.34	Not Significant	Do Not
Female	3.11	0.68			Reject H_0

The link between gender and mathematics anxiety has been extensively researched, with many studies concluding that there are no gender differences in Mathematics anxiety. Girls have a higher degree of overall and testing math anxiety than boys; however, there was no gender difference in learning math anxiety [42]. As a result, the type of math anxiety appears to influence the gender disparity in math anxiety. Girls have more anxiety when they are tested in math than boys, but when children study math, they experience the same level of anxiety. Early school-age girls are more likely than boys to experience anxiety linked to math testing because they have higher test anxiety and overall anxiety [27].

In general, several variables can contribute to mathematics anxiety. For example, unpleasant teaching and assessment tactics for students, such as time testing [43] and assigning mathematics as punishment [44], may affect the growth of mathematics anxiety at all levels. Although mathematics anxiety may have begun early in life, research has demonstrated that it is possible to lessen mathematics fear at all stages of education [45]. Given the importance of appropriate mathematics-related instruction and teachers' enthusiasm for mathematics in developing students' mathematics anxiety [46], reducing pre-service teachers' mathematics anxiety is critical. It may help reduce students' mathematics anxiety [47]. More active learning (such as group work) may also help to alleviate anxiety [34].

Differences in the Level of Mathematics Resiliency

Table 5 shows the results of the difference in the level of mathematics resilience of Grade 9 students when grouped according to sex. The result rejects the hypothesis that there is no significant difference between the level of mathematics resilience of Grade 9 students when grouped according to sex. With a 0.04 *p*-value, it shows that the difference between the level of mathematics resilience of Grade 9 students when grouped according to sex is significant. This further means that male Grade 9 students are more resilient than female Grade 9 students in mathematics.

Table 5. Significant difference in the level of mathematics resilience of Grade 9 students when grouped according to sex

Variable	\bar{x}	SD	<i>p</i> – value	Significance at $\alpha= 0.05$	Decision
Sex					
Male	3.88	0.62	0.04	Significant	Reject H_0
Female	3.77	0.63			

This result conforms to the study of Rahayu et al. [48]. Male students' average mathematical resilience was stronger than female students.

This finding supports the hypothesis that despite efforts to engage girls differently, boost achievement and participation rates, and eliminate detrimental gender bias messages, there is still a lack of trust in girls in mathematics [49]. Despite their math accomplishments, girls have less confidence in their talents than boys [50], and males have stronger self-esteem than females [51]. This is demonstrated when students are given a math problem and asked how confident they are in their answers. Boys express assurance and confidence in their answers even when they are incorrect. In contrast, girls express uncertainty or lack self-confidence when their answers are correct; some even request opportunities to re-examine their work.

Some females struggled to articulate the significance of mathematics to their concept of what it meant to be a mathematician. While they recognized various authentic mathematical activities at home, kids were overwhelmed by quantity, calculation, pace, and processes, and mathematics was viewed as desk-bound and isolating. They learned to understand their mathematical identities through interactions and comparisons with others, as well as mathematical characterizations.

Differences in the Level of Performance in Chemistry

Table 6 reveals the Significant difference in the level of Performance in Chemistry of Grade 9 students when grouped according to sex. Results presented below indicate the acceptance of the stated hypothesis before the survey that there is no statistically significant difference in the level of performance in Chemistry by the respondents when grouped according to sex.

Table 6. Significant difference in the level of Performance in Chemistry of Grade 9 students when grouped according to sex

Variable	\bar{x}	SD	<i>p</i> – value	Significance at $\alpha= 0.05$	Decision
Sex					
Male	85.97	4.07	0.34	Not Significant	Do Not
Female	85.41	3.53			Reject H_0

With a p -value of 0.34, this result shows that the difference in the level of performance in Chemistry by the male and female respondents is not significant. This further implies that although male ($\bar{x}=85.97$, $SD= 4.07$) is more proficient than female ($\bar{x}=85.41$, $SD=3.53$) in the level of performance in chemistry, their proficiency level is almost the same. With this, it is indicated that the relationship between the performance in chemistry and Mathematics anxiety and resiliency could be the same for both male and female respondents based on their chemistry performance.

Relationship between level of Mathematics anxiety and Mathematics Resiliency of Grade 9 Students to their Chemistry Performance

Results show that the Mathematics Anxiety of the Grade 9 Students is not significantly related to their chemistry performance ($r=-0.039$, p -value=0.496). This is similar to the Grade 9 students' Mathematics resiliency ($r=0.031$, p -value=0.596). This further denotes that the anxiety and resiliency of Grade 9 students towards mathematics do not affect their ability and knowledge acquisition of the subject and that student experience of mathematics anxiety is not closely related to their academic achievements.

Table 7. Significant relationship between level of mathematics anxiety and mathematics resiliency of the Grade 9 students to their performance in Chemistry

Variable		Anxiety	Resiliency
Resiliency	Spearman's rho	-0.039	-
	p -value	0.503	-
Performance	Spearman's rho	-0.039	0.031
	p -value	0.496	0.596

This finding is consistent with Musa & Maat [52], which indicated that Mathematics anxiety was experienced by both high- and low-achieving math students. However, high-achieving students' primary influence on Mathematics anxiety was motivating, whereas low-achieving students' key contributors were inadequate math competency and self-skills.

Students become agitated and frustrated while undertaking arithmetic activities because of difficulty or failure to understand the task. However, students, particularly those who excelled, stated that doing enough regular exercises is critical to improving their arithmetic skills. The continuous arithmetic practice has been shown to assist people in overcoming Mathematics anxiety [53].

5. Conclusions

Students in Grade 9 do, on average, suffer anxiety in their Mathematics classes; however, these students can manage and control the anxiety they feel toward Mathematics. Concerning students' anxiousness with mathematics, male and female students have nearly similar experiences, and therefore, no substantial differences are indicated in their anxiety levels toward mathematics. Nevertheless, the obtained means represented in the data suggest that female students have experienced a somewhat higher level of anxiety in mathematics than their male counterparts. This suggests that male students are better equipped to deal with the anxiety that comes with doing mathematics compared to female respondents.

The findings also concluded that students in Grade 9 classes are robust enough to handle a crisis in learning mathematics. They already have a constructive and flexible attitude toward mathematics, enabling them to continue their education despite the challenges of the

pandemic especially. Regardless of their gender, they can overcome the problems that mathematics presents and the various obstacles they have met concerning mathematics. Nevertheless, male students in Grade 9 classes have a better perspective in addressing mathematical challenges when their obtained means are considered. They can deal with mathematical difficulties much better than their female counterparts. This is substantiated by statistical tests showing a significant difference between the two groups.

On the other hand, students who had taken Chemistry as part of a curriculum in Grade 9 were already at a proficient academic level in the subject. This indicates that they have achieved a high level of mastery in the subject, particularly in the various subject matters covered in their Chemistry lessons. In other words, they did well for themselves in their Chemistry class. However, based on the investigation results, females are more competent than males. This indicates that girls have a higher level of success in Chemistry, as measured by their academic achievement than males.

In conclusion, the level of anxiety and resilience that students in Grade 9 mathematics experience are not associated with their academic progress in Chemistry. The fears and difficulties students encountered while learning mathematics did not affect their academic performance in Chemistry. According to the findings of this research, a student's level of academic success in Chemistry is unrelated to the level of anxiety they have regarding mathematics or the amount of resilience they possess.

6. Recommendations

It is recommended that students in Grade 9 classes cultivate more positive attitudes toward the subject of mathematics, pandemic, and post-pandemic because their level of mathematics anxiety is about average. This indicates that these students can manage and control their anxieties regarding Mathematics. Teachers of Chemistry and Science are also urged to make their students feel comfortable and help them build a greater sense of self-assurance in Mathematics to reduce their anxiety over this topic.

It was shown that students in the ninth-Grade class have a high level of resilience in Mathematics. This indicates that these students already have a positive adaptive stance toward Mathematics, which enables them to continue learning despite challenges. It is recommended that students understand how essential it is to learn Mathematics, particularly in this age of intense global competition in marketing and business, both of which are mathematical. This is especially true because both fields rely heavily on Mathematics. Educational stakeholders, such as the family and the community's fundamental unit and teachers, should guide their children toward acquiring mathematics learning.

It was determined that students in Grade 9 classes were proficient enough in their academic success in Chemistry, indicating that they strongly understand this topic. Along these lines, the findings of this study propose that students try to learn more meaningful content related to this area of study. Similarly, chemistry and other sciences teachers should be pushed to work harder and put in more effort to ensure that their students receive a high-quality education in chemistry.

Because the level of mathematics anxiety experienced by students in Grade 9 students and their level of mathematical resilience are not related to academic achievement in Chemistry, as indicated by the findings of other studies that are comparable to this one, it is recommended that a study that is comparable to this one be carried out in some other city school divisions in order to either confirm or deny the findings of the present study and to make a contribution to the body of knowledge in Science education, more specifically in Chemistry.

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