



## Importance of Teachers' Perspectives in Teaching Biology in Singapore (2015-2016)

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**ABSTRACT:** This chapter aims to develop an in-depth understanding of the perspectives that secondary school teachers hold regarding the biology curriculum in Singapore. By exploring teachers' views on the curriculum's design, content, and delivery, the study seeks to provide valuable insights that can inform both educational policy and future research as well as inform the preparation and training of secondary school biology teachers. Specifically, it addresses issues related to the teaching of secondary school biology, including the challenges teachers face in implementing the curriculum. Data for this research was collected between 2015 and 2016 through semi-structured interviews conducted with teachers from randomly selected government secondary schools across Singapore. The data were subsequently analysed using qualitative data analysis methods which facilitated the identification of key themes and patterns in teachers' perspectives. The findings from this study aim to contribute to ongoing discussions about curriculum development and teacher education in Singapore, offering evidence-based recommendations for enhancing the teaching and learning of biology at the secondary level. By highlighting teachers' voices, this research underscores the importance of involving practitioners in curriculum evaluation and reform efforts, ensuring that policy decisions are informed by those who engage directly with students in the classroom.

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### 1. INTRODUCTION

Biology as a teaching subject in secondary schools in Singapore has a relatively short subject history compared with physics and chemistry. Recent advancements over the last two decades have led to an exponential increase in the content of biological knowledge [1]. Biology was initially perceived by some scientists and educators as a subject with little relevance and significant only in preparation for a medical career. However, as described by [2], the purpose of biology education is to prepare students for life and living as well as for an understanding of the environment. Biology is not only concentrated on the discovery of new information but the utilization of acquired knowledge for useful purposes of everyday life. The issues of today are increasingly bio-social in nature and biology teachers have an increasingly important role in preparing students for the future.

Whilst there has been some research conducted in relation to the teaching and learning of general sciences in the Singaporean context [3], research undertaken to understand the teaching of biology as a secondary school subject in Singapore remains neglected, specifically in the area of the perspectives of the teachers. The issues teachers face have a direct impact on how the subject is taught in the classroom, and consequently how the students learn the subject [4].

This study aims to develop an understanding of the perspectives secondary school teachers have regarding the curriculum of biology in Singapore. It aims to provide insights to inform considerations for policy and further research, specifically in the teaching of secondary school biology, and the preparation and training of secondary school biology teachers. Data for this research was collected using four semi-structured interviews at four randomly selected government secondary schools in Singapore. A total of twelve teachers were interviewed during the period of 2015 to 2016. The data were analysed using qualitative data analysis methods described by [5].

## 2. LITERATURE REVIEW

### 2.1 Significance of Teachers' Perspectives in Biology Education

Teachers' perspectives are central to understanding how curricula are interpreted and implemented in classrooms. Their beliefs, experiences, and pedagogical content knowledge directly shape the quality of science education [6]. In the context of biology, where concepts are abstract and content rapidly evolving, teacher input becomes even more vital [7].

In Singapore, where education is tightly governed at the national level, incorporating teacher feedback ensures curricular reforms are grounded in classroom realities. This alignment helps maintain coherence between policy and practice, ensuring that intended learning outcomes are realistically achievable [8 ; 9].

### 2.2 Teachers' Perceptions of Curriculum Changes

Curriculum change often aims to modernize content and encourage inquiry-based teaching. However, successful implementation depends on how well teachers understand and accept these changes [10]. Resistance can arise from misalignment with teachers' existing pedagogical approaches or insufficient professional development [11]. In Singapore's biology curriculum, increased emphasis on conceptual understanding and real-world applications required teachers to adjust their teaching strategies—often with mixed responses [9].

[12] found that teachers' perceptions of creativity in science are also shaped by curriculum design. If the curriculum does not explicitly support creative and inquiry-based learning, teachers may struggle to implement such strategies, despite their pedagogical value.

### 2.3 Impact on Teaching Practices and Student Outcomes

Teacher perceptions influence not only how they teach but also what students learn. Positive engagement with the curriculum often leads to more active and responsive teaching, enhancing student interest and understanding in biology [13]. Conversely, when teachers feel disconnected from curricular goals, their instructional approaches may become overly rigid or exam-focused [9].

[7] emphasize that teacher beliefs about biology—often shaped by their own educational experiences—can affect how they approach topics such as evolution, genetics, and environmental science. Understanding these perspectives allows curriculum developers to better support teachers in delivering complex content.

### 2.4 Collaborative Approaches to Curriculum Implementation

Collaborative professional development has proven effective in helping teachers adapt to curriculum reforms. [6] demonstrated how learning communities in Singapore enabled teachers to co-construct knowledge, troubleshoot implementation challenges, and reflect critically on their practice. Such collaboration fosters a sense of ownership and professional agency, which are essential for successful reform [11].

Shared experiences also allow biology teachers to pool resources and pedagogical strategies, especially in areas where the curriculum introduces new or complex scientific ideas. This collective effort can lead to more consistent teaching quality across schools [8].

### 2.5 Need for Ongoing Research and Feedback Mechanisms

Sustained feedback mechanisms between policymakers and teachers are essential for evaluating the effectiveness of curriculum changes. Ongoing research into teachers' perspectives can reveal whether reforms are meeting their intended goals and how they might be improved [8]. In Singapore, studies have shown that when teachers are consulted and supported, they are more likely to embrace innovation and refine their teaching accordingly [6 ; 9].

By listening to the voices of teachers, curriculum developers can create more adaptive and contextually relevant biology programs that address both national educational goals and local classroom needs.

## 3. METHODOLOGY

This study is located in the interpretivist paradigm. The interpretivist paradigm directs the researcher in understanding the meaning of human and social actions [14]. An important idea behind the interpretivist paradigm is that reality is socially constructed and therefore, what we understand is always negotiated within cultures, social settings, and relationships with other people. With the interpretivist approach, the researcher is the primary data-gathering instrument where carefully constructed questions aimed at understanding a phenomenon through semi-structured or open-ended interviews are often used. Another characteristic of the interpretivist approach is that it can generate a significant amount of data from a small number of participants which is relevant for this study. One way researchers can apply the interpretivist paradigm is through the use of the concept of perspectives. The theoretical position located within this broader research paradigm is symbolic interactionism. Symbolic interactionism, which stresses the way individuals see, define, interpret and react to a given situation [15], is consistent with this research position. Indeed, symbolic interactionism is a major theoretical position within the interpretivist paradigm. It is both a theory and an approach to the study of human behaviour [16]. People construct meaning by interpreting their social interactions [17] and communicate these meanings.

### 3.1 Data collection

Face to face interviews were conducted from the period September 2015 to March 2016. Permission was granted from the research and planning division at the Ministry of Education in Singapore in September 2015. Permission was also requested from the school principal and the teachers before the commencement of the interviews. Four semi-structured group interviews were conducted with three teachers each time so that a total of twelve teachers were interviewed. Semi-structured interviewing was chosen for three reasons; firstly, the participants are allowed to react and comment on the guiding questions [18] without strict restrictions. This allowed the teachers to feel comfortable to share their perspectives; secondly, semi-structured interviews have proven to be optimal in providing "people's perceptions, meanings, definitions of situations and constructions of reality" [19]; thirdly, this type of interview allows the interviewer to pre-determine the direction of the interview and elicit appropriate responses from the interviewee to ensure a valid set of data.

Notes and recordings were taken during the interviews, and inductive inferences were made to allow the researcher guidance in determining further questions [18]. Each interview lasted for approximately 90 minutes. The recorded interviews were subsequently transcribed. Each participant was identified by a numerical code on the transcript to ensure anonymity.

### 3.2 Data analysis

Data for this study were analysed using the general qualitative data analysis method described by Miles and Huberman. The Miles and Huberman method describes a concurrent three-step process: data reduction; data display; and drawing and verifying conclusions. Data reduction or data condensation refers to the process of selecting, focusing, simplifying and abstracting the data without the loss of significant information [19]. Data display involves analysing and organising the data in a presentable format. Drawing and verifying conclusions is the third part of the Miles and Huberman approach to data analysis. Once all the data is analysed, the conclusions are verified and become more grounded.

The Blackledge and Hunt framework [20] for perspectives informed the work of the researcher. This concept involves the notions of aims and intentions, significance, reasons and strategies [20]. The framework for perspectives was useful in framing the interview guide which was developed from the guiding questions. The numbers and letters that appear in parenthesis in this article refer to the coding system for identifying the transcripts of interviews.

### 3.3 Research Question

This study aims to develop an understanding of the perspectives secondary school teachers have regarding the curriculum of biology in Singapore. In line with this aim, the research question is as follows –

*What perspectives do secondary school teachers have regarding the curriculum of biology in Singapore secondary schools?*

## 4. FINDINGS

The teachers' raised two main concerns with the biology curriculum and syllabus. The first concern was based on the *introduction of the topic of molecular biology* into the syllabus. The second concern focused on the *introduction of the inquiry approach* into the curriculum. The numbers and letters that appear in parenthesis in this article refer to the coding system for identifying the transcripts of interviews.

Before describing these concerns, it is important to provide a brief definition of 'curriculum' and 'syllabus' and to describe the curriculum review process in Singapore. In a theoretical sense, curriculum refers to what is offered by the school or college. However, in the practical sense, it has a wider scope which covers the knowledge, attitude, behaviour, manner, performance, and skills that are imparted in a student. The syllabus is defined as the documents that consist of topics covered in a particular subject which serves to *support* the curriculum. The syllabus focuses more on the topic and the parameters the teacher should follow when teaching.

The science curriculum in Singapore undergoes a six-year review cycle. The Curriculum Planning and Development Division of the Ministry of Education in Singapore conducts zonal teacher networking sessions in which the division officers elicit feedback from the teachers regarding the syllabus. With this feedback, a syllabus review is conducted with a syllabus review committee. The committee, headed by the Minister of State for Education, comprises representatives from Ministry of Education, Singapore Examinations and Assessment Branch officers, curriculum planning officers, lecturers from the National University of Singapore as well as the National Institute of Education and government school teachers. Curriculum planning officers present their findings to the syllabus review committee. Syllabus changes will be informed to lecturers from the National Institute of Education and current heads of science departments in school. This will allow the National Institute of Education to adjust their training and courses for beginning teachers and in-service teachers according to the changes (P1:4:6:1). The heads of departments then highlight the changes to the in-service science teachers for appropriate execution during teaching.

### 4.1 Introduction of molecular biology

The biology syllabus was reviewed and changes were implemented in the year 2000 to ensure that concepts and skills fundamental to students' access to the new fields of life sciences were incorporated [1]. In 2008, the introduction of molecular

biology topics into the secondary school biology syllabus was to ensure that the biology syllabus moved together with the growing international landscape of life sciences.

According to [21], arguably the most significant change in biology over the past century has been in molecular biology. Molecular biology can be described as a perspective that biologists use to explain the phenomena they are studying. [22] has suggested that molecular biology should not be considered as a sub-discipline of biology, but as a specific level of explanation which is *demonstrated* through sub-disciplines of biology such as molecular genetics. Life sciences involve the scientific study of life and organisms, such as microorganisms, plants, and animals including an extended aspect on molecular genetics, specifically on the study of Deoxyribonucleic Acid (DNA).

In addition, [20] adds that the role of molecular biology education in the formulation of an understanding of molecular phenomena is fundamental to understanding key processes at higher levels and is essential for all life science studies. As [23] stated, “understanding genetic phenomena entails understanding how mechanisms and interactions at the molecular (genes, proteins) and micro-levels (cells) bring about effects at the macro-level (organism, population)”.

Schools were provided with more support and funding to support this review of syllabus. In 2003, a Deoxyribonucleic Acid (DNA) centre was set up at the National Institute of Education to address the growing emphasis on life sciences and the need to train and educate teachers in these concepts [24]. In 2003, the DNA Learning Lab was opened at the Singapore Science Centre. The centre collaborated with the DNA Learning Centre at Cold Spring Harbour in New York to distill cutting-edge research work in the life sciences (e.g., DNA extraction, bacteria transformation) into simple experiments accessible to young students [1].

#### 4.1.1 Inclusion of the molecular biology topics.

The syllabus was adjusted to allow the inclusion of the molecular biology topics which inadvertently saw the *reduction of other biology topics*. These topics such as muscles, teeth, and bones were considered to be classical biology topics by the senior biology teachers. This reduction raised a concern for the teachers. The move was not without its detractors who were concerned that there was too much emphasis on molecular biology at the expense of curriculum time for learning about classical macro-biological systems such as ecosystems and animal physiology [1]. Such debates also reflected the ongoing tensions in deciding on the scope of the national curriculum. The Ministry of Education has often maintained the need for the curriculum to remain concise such that any additional contents introduced to update the curriculum have to be accompanied by the corresponding removal of topics, which often becomes a difficult decision to take as it has implications for the different stakeholders such as the teachers. Some of the teachers interviewed felt that the objective of biology education is to prepare students for life and living and an understanding of the environment and not so much an understanding of molecular biology.

*Biology is the study of life and the relationship of living things as well as an appreciation of man and his environment. (S2:21:7:1)*

Whilst the teachers recognised that molecular biology brings into the classroom modern science concepts which are relevant and important in ensuring Singapore is in alignment with new scientific discoveries, they expressed concern with the reduction of the classical biology content.

*The world is changing; the science field is changing. There are so many discoveries. However, the essence of biology education is in the study of animal and plant physiology. (S1:4:3:1)*

The sentiment shared was consistent with most of the teachers interviewed. The reduction in classical biology content was inevitable in the face of a changing landscape of science education; however, most of the teachers were concerned that this reduction of content would have a detrimental impact on students' mastery of the content of biology in its entirety. In addition, some teachers commented that molecular biology is not consequential to the holistic learning of biology at the secondary school level. Molecular biology topics are observed to be covered in more detail at the post-secondary level. Therefore some teachers questioned the necessity of the implementation of molecular biology topics at the secondary school level.

Some teachers commented on the *abstract nature* of the molecular biology topics. The teachers questioned the students' level of scientific literacy at a secondary school level and its alignment to understanding molecular biology. Scientific literacy in this regard refers to the ability of the students to understand complex scientific theories. One of the main attributes of scientific literacy according to [25] and [26] is the ability to understand scientific terms.

*The students have trouble understanding some of the terms. They are similar in sound and in spelling and they are often confused. One example is phenotype and genotype. (S1:5:10:2)*

Students are likely to find more difficulties with terms in biology than in chemistry or physics [27]. This concern resonates with the concern shared earlier questioning the necessity of teaching molecular biology at the secondary level instead of post-secondary. The maturity of mind could perhaps aid in the scientific literacy of a student and allow for more effective acquisition of an abstract

topic such as molecular biology. The invisibility and inaccessibility of genetics concepts make the subject complex and abstract [28] and therefore difficult to understand.

*The students have trouble understanding the concept of genetics. They are not able to see physical DNA and therefore have trouble visualizing it. (S3:23:4:1)*

According to [21], this invisible phenomenon is difficult for students to understand, therefore making reasoning about it challenging. In addition, [23] highlighted the fact that there are several different levels of organization within the molecular biology level that further confuse students.

#### 4.1.2 Teaching of the molecular biology topics.

The teachers interviewed read different science majors in a university such as microbiology and biotechnology. However, after teacher training at the National Institute of Education (NIE), they all assumed the position of biology teachers. There are differences in the teaching of biology, chemistry, and physics. However, the key ideas of assessment, nature of science, science laboratory work, conceptual understanding and key strategies (such as questioning, scientific argumentation, flip classrooms etc.) in all of the different sub-disciplines are addressed at the NIE [29].

According to [29], an assumption is made that teachers possess current and adequate subject mastery since the pre-requisite for admission into the NIE program is a first degree in the relevant field. As such, specific content of physics, chemistry and biology is not included in the program. [29] explains that although this assumption may be largely valid, there are instances where this assumption breaks down.

Therefore, some of the teachers felt they were *insufficiently trained* to teach the molecular biology topics that were introduced. According to [30], there are four specific areas of expertise that are required for the effective teaching of molecular genetics. Firstly, subject matter expertise; secondly pedagogical content knowledge; thirdly interpersonal expertise; and lastly moral expertise. Subject matter expertise refers to content knowledge and pedagogical content knowledge is essential to represent the subject matter in a way that the student conceptions and learning difficulties concerning that specific subject matter are accounted for. Interpersonal expertise refers to the ability to build relationships with students [31] and moral expertise refers to the ability to clarify the normative component of socio-scientific issues [30].

Most of the teachers interviewed expressed difficulty in the first and second area of expertise as stated by [30]. The concern cited was that they did not have expertise concerning the subject matter. The introduction of the molecular biology topics forced the teachers to re-learn the molecular biology concepts. An improvement or re-learning is required not only for the content knowledge of the teachers but also pedagogical knowledge [29] to suit the incorporation of molecular biology into the syllabus. Some of the teachers interviewed expressed increased levels of anxiety and stress when re-learning of content had to take place.

*It becomes very stressful for teachers because re-learning has to take place. We have all been trained in a particular field, but when new science comes in, we are expected to re-learn a large amount of knowledge (P1:4:3:1).*

In-service teachers struggled to find the time to attend the courses and workshops planned for them. In addition to marking and planning for lessons, the teachers are expected to attend courses and workshops to facilitate in their re-learning process. Workshops and courses are provided by the Academy of Singapore Teachers as well as the National Institute of Education for in-service teachers. The academy aids in driving pedagogical leadership to raise the level of professional practice in the classroom and expertise across the system.

*We relied on textbooks and the internet mostly, to update ourselves with regards to the content. Also, of course, we helped one another (S1:10:4:2).*

It is important to determine subject matter expertise when teaching molecular genetics. This would include current school subjects as well as recent content from research discoveries [30]. Therefore, it is essential for teachers to keep abreast of the current content knowledge in the area of molecular genetics.

Teachers also raised the concern of *insufficient resources* required to teach effectively molecular biology topics. For example, the studying of DNA is often aided by experiments, which are hands-on activities conducted in the science laboratories, involving the Polymerase Chain Reaction machine. Due to high cost, very few schools own such a machine.

*To teach DNA effectively, there would be a need for the PCR machine. However, only one school in our cluster owns one (S2:14:3:1).*

In this instance, a cluster refers to a group of schools which are located within a specific area in Singapore. Cluster schools participate in networking, sharing, and collaboration with each other to raise the capacity of the leadership teams and the level of performance in each school. However, due to occasional logistical constraints, such as limited time, teachers may not be able to utilise teaching resources such as the Polymerase Chain Reaction machine from the cluster schools.

As mentioned earlier, pedagogical content knowledge is an important tool in the teaching of molecular genetics. Some of the teachers expressed a concern that their repertoire of pedagogical skills was insufficient in allowing an accurate representation of the subject matter. This also stemmed from their lack of confidence in the content. Many of them expressed the attempt at adopting alternative methods of investigating the concept of DNA. Some used videos and animation while others chose to conduct simple science experiments in the science laboratory. However, the teachers did comment on the absence of the spirit of discovery and inquiry in explaining the molecular biology concepts due to the limited resources and pedagogical content knowledge.

*The students are so bored watching video after video. They prefer to perform hands-on activities. However, with the DNA chapter, it is very difficult (S2:30:3:2).*

Teachers also indicated that the materials provided, such as textbooks and workbooks, did not provide a suitable mode of assessment for the molecular biology topics. The questions in the workbooks were based on low-level questioning skills and were insufficient in assessing the students on inquiry skills with regards to the molecular biology topics.

*The questions were insufficient. We used our own worksheets for the topic on Molecular Genetics and Heredity (S3:8:3:1).*

As mentioned earlier, a DNA centre was also set up at the National Institute of Education in 2003 to provide teachers and students with hands-on experience of investigations in the area of life sciences [24]. A similar DNA Learning Lab was set up at the Singapore Science Centre in 2003 as well to make the knowledge of life sciences accessible to younger students. Unfortunately, the teachers required more assistance in their day to day classroom teaching of the topic. The Curriculum Planning division also published a book with biosafety guidelines to provide schools with information on the handling of biological samples and contamination. However, the teachers felt that the book served more as a guide for safety measures rather than support in teaching and learning.

#### 4.2 Inquiry approach

A significant shift was made in the curriculum to give greater emphasis to teaching and learning science by inquiry to nurture students' curiosity, inquiring minds, higher-order reasoning skills and problem-solving skills [32]. There was greater emphasis on using hands-on and more open-ended investigations to encourage students to move away from mechanically following instructions to more self-directed learning and creative thinking [33]. The objectives of the inquiry approach will be discussed in the next section, followed by the concerns the teachers expressed with regards to the implementation of the inquiry approach.

The 2008 revamp in curriculum gave explicit emphasis to inquiry in the teaching of science. Science as inquiry suggests that science teaching is no longer only about students' acquisition of content knowledge but also about skills, strategies, and habit of mind associated with decision making and problem-solving [34]. The science syllabus was adjusted to free up curriculum time for the introduction of thinking skills [1].

Most of the teachers interviewed are supportive of the inquiry approach. They articulated that science teaching should no longer be only about students' acquisition of content knowledge.

*It is important for students to learn how to creatively seek knowledge rather than merely memorizing content from textbooks (S3:9:3:1).*

However, they highlighted certain concerns that affect their execution and their inclusion of the inquiry approach in their classroom teaching. The enactment of science as inquiry have brought to the surface various difficulties and tensions [34]. Despite structured approaches to support the implementation of the inquiry approach, research in international communities of science education shows that the implementation has been a daily struggle for science teachers [35]. The implementation of science as inquiry is challenging due to reasons such as students' attitudes towards the approach, teachers' competencies and belief system and lack of administrative support in the area of assessment implementation in alignment with the inquiry approach. These challenges are discussed in turn.

Some of the teachers interviewed held the view that students were not ready to participate in inquiry teaching because the approach was new to them. Students' attitudes towards the inquiry approach were observed to be indifferent due to the fact that they are accustomed to teaching that provided model answers in preparations for examinations [34].

An important difference between the traditional classroom and an inquiry-based classroom is the role played by the students [36]. In traditional classrooms, students play a passive role as recipients of knowledge. An inquiry-based classroom aims to develop students as active learners who take ownership of their learning. Such autonomy in their learning may allow them to set the direction of how the lesson progresses. In order for the teacher to orchestrate inquiry-based learning, they must know where their students are

located in the learning journey [37]. This requires the teacher to elicit information actively and continuously about students' learning [38]. Some of the teachers interviewed expressed the concern that the upper secondary students (15-16 years old) were observed to be non-receptive to the inquiry approach as compared to the lower secondary students (13-14 years old).

*The lower secondary students are still at an inquisitive age where they are willing to take part in the inquiry-based activities without much hesitation (S4:10:2:2).*

The teachers teaching lower secondary students are not limited by time to complete the syllabus; therefore, there is the freedom of exploring inquiry approaches in their teaching. The teachers also do not feel the pressure of national examinations for the lower secondary students and therefore are willing to explore more alternative approaches towards science.

*The stakes are lower at the lower secondary level. That gives us the space and time to explore the inquiry-based activities. (S3:11:2:1)*

The upper secondary students, on the other hand, are more concerned about their national examinations. They would rather be taught the content in its entirety without the frills of an alternative pedagogical approach such as the inquiry approach. One teacher highlighted that this attitude might stem from the pressure they receive at home. Their parents are particularly concerned about the national examinations and the academic performance of their children.

*The students are worried about failing, and they want to know how to do well academically. Some of their parents have very high expectations for them (S2:40:2:1).*

Another teacher cited that the upper secondary students have developed an attitude of complacency in their learning. They tend to expect the answers rather than think through the questions posed by the teachers. There is a lack of desire to self-regulate their own learning, and instead, they are more inclined to expect answers from their teachers. Hence, they consider the inquiry approach to be tedious and time-consuming.

*The students expect the 'textbook' answers even before trying the questions on their own. (S4:33:4:1).*

After conducting a lesson incorporating the inquiry approach, one of the teachers interviewed was asked about the objective of the inquiry approach by some of her students questioned. The students queried further on why the lesson could not be taught in the regular didactic manner. With reluctance to adhere to the inquiry approach, students are non-participative, and this posed a further challenge for the teachers.

*One of my students said to me, 'Why can't you just tell us what is important for this chapter, what will come out for the exams? Why do we have to do this activity?' (S1:28:2:3)*

One teacher shared that implementing the inquiry approach requires a culture that needs to be cultivated. The students have conformed and found comfort in the didactic manner of teaching. Displacing the stability they acquire from didactic teaching and placing them in a setting of unpredictability with the inquiry approach is an arduous task.

In addition to the above-stated concerns, there were a number of teachers who highlighted that the students' weak grasp of the content added to the inability to implement the inquiry approach during lessons. The students are not sufficiently equipped, content-wise, to answer the inquiry questions posed at them.

*I have had students who cannot even understand the simple concepts in the class. If I were to incorporate inquiry into the lesson, these lower ability students would lose out (S2:9:3:2).*

As mentioned by the teacher quoted above, some students may not benefit from a class-wide implementation of an inquiry approach. Higher-ability students, according to the teachers, would best benefit from inquiry teaching, whereas lower- and middle ability students could be disadvantaged. Some teachers felt that the inquiry approach was forced fit into the curriculum without addressing the different learning styles of the students.

However, this concern may be a biased perspective of what the teachers deem the students can handle based on their behaviour in class or their attitude towards learning. There is a general biased perception that science as inquiry can be implemented only for students with above-average abilities [39, 40]. This perception may not be true in all cases. The inquiry approach focuses on allowing the students to create their knowledge and develop perceptions of content. It holds little or no regard to the perceived intellectual

abilities of the students. In the next section, the teachers' concerns regarding their own competencies to implement the inquiry approach are discussed.

While students in Singapore have been doing fairly well in international benchmarking studies, such as the Trends in International Mathematics and Science study [41], research into classroom practices have brought to the surface areas for improvement. According to a study by [42], Singapore's science classrooms displayed a largely 'didactic, traditional and rote reproductive character of pedagogy', which falls short of the Ministry's call for a more student-centric active learning environment [1].

The intentions of curriculum developers or teachers, as is increasingly conceded, often do not map well onto actual classroom practices or enacted curriculum [37]. Attention has to be paid to another aspect of curriculum development that has been less emphasised which is the curriculum implementation.

The teachers interviewed shared that they were limited by their own competencies with regards to implementing the inquiry approach. Teachers are not able to adapt to implementing alternative curriculum approaches if they do not have sufficient knowledge on the subject matter of science and its practice as a form of inquiry [43]. The teachers' interpretation and implementation of curriculum changes may not always be consistent with the intent and the expectations of the implementation body [44]. Therefore, it is paramount that the teachers understand the approach and how to implement it (P1:3:5:1). The issue with the teachers implementing the inquiry approach on their own is that the intended outcome of the approach may not be realized in its entirety. One of the main reasons for the number of workshops and course organised by NIE and AST was to ensure the teachers' implementation of the inquiry approach is aligned with the intended outcome [1].

Some of the teachers interviewed voiced the concern that they are not confident to deliver an inquiry-based lesson because of this lack of understanding of the inquiry approach. Therefore many of them struggled in producing a suitable inquiry-based lesson.

*I don't have much experience in implementing an inquiry lesson. I am so used to teaching a teacher-centred lesson (S2:10:5:1).*

The National Sciences and Science Education Academic Group at the National Institute of Education developed five customised courses on the inquiry approach since 2007. The objective was to ensure the professional development of the teachers in understanding the inquiry approach. However, the in-service teachers found it very challenging to find the time to attend these courses. Instead, the teachers continued to struggle to implement the inquiry approach on their own.

*We talked amongst ourselves regarding the best way to implement inquiry in biology. There was hardly ever a chance to speak to teachers from other schools (S2:10:2:1).*

Teachers feel that inquiry may not be the best approach to teaching biology. Most of the teachers interviewed feel overburdened and lacked the time to meet the demands of the inquiry approach.

Another issue that was highlighted by the teachers interviewed was that the inquiry approach does not have a proven record of positively contributing to the students' academic results. The teachers were concerned that if they abandon their trusted approach of drill and practice, the students' academic results may be affected.

*What if the students don't understand the content when it is taught in another manner? We would have to revert to the regular style of teaching. Quite a lot of time wasted. (S2:16:7:1)*

The high-stakes national examinations exert great demands on the teachers' time. While some of them believe that an inquiring mind is valuable, it does not guarantee good performance in examinations. In order to meet performance expectations, teachers feel the need to do minimal inquiry teaching and instead focus on more direct forms of teaching. The lack of teacher belief affected the successful implementation of the inquiry approach. Beliefs are based both on the teachers' interpretation of the interplay between reform innovations and actual classroom events and as filters for decision-making on instructional goals and classroom management [45]. The teachers have a strong sense of accountability towards the students and their academic results. This was one of the reasons why some of the teachers interviewed refrained from adopting the inquiry approach at upper secondary level classes in its entirety. The next concern related to the inquiry approach is on the issue of assessment.

Teachers feel that ensuring congruence between the inquiry approach and *assessment* is one of the important aspects of ensuring effective implementation of the inquiry approach. However, many of the teachers interviewed expressed that the current assessment framework and the inquiry approach are incompatible. The current assessment practice does not encourage inquiry. Instead, it focuses on recall and application of content, more summative style assessments.

*When inquiry was first introduced, the majority of the questions in the paper require the students to memorize or recall content. Lately, there seems to be more thinking questions (S2:38:2:3).*

However, it was noted through the interviews with the teachers, that there had been an increase in data based questions in the national examinations in recent years. This inclusion of data based questions allows for a more formative approach to assessment.

Another struggle that was highlighted was that the teachers have a lack of understanding of formative assessment. Therefore even though they are aware that formative assessment would ideally support the inquiry approach, they are challenged in ensuring that the assessments they are administering are truly formative.

*I have created worksheets and quizzes that I think are in alignment with the inquiry approach, but I am still not sure if it is formative in nature. This makes me question whether I should implement it. The other thing is that we have no sample worksheets or quizzes in formative style to refer to (S4:11:9:1).*

The teachers raised the concern that there is a lack of resources to support the inquiry approach. Providing a sample of formative assessments would greatly alleviate the concern and the lack of knowledge of formative assessment.

## 5. DISCUSSION

Struggles teachers face in effective syllabus delivery can be attributed to insufficient pedagogical and content knowledge. Pedagogical content knowledge is fundamental for the effective teaching of science. It includes an understanding of what makes the learning of specific topics easy or difficult. There are two similar interpretations of pedagogical content knowledge. It has been shown by [46], that the current teaching approaches in biology follow simplistic linear conceptions and students learn simplified versions of the content that are not adequately representative of biological natural systems. As teachers, we are in a constant battle to resolve the dilemma between the simplicity of teaching and the complexity of the content. In an effort to simplify the content, it is presented to students as a one-dimensional knowledge structure which effectively denies students access to understanding. Therefore, it is essential that the pedagogy used accurately reflects the intention of the curriculum. In the event it does not, students' understanding is compromised.

The most significant change in biology content over the past century has been in molecular biology. Molecular biology can be described as a perspective that biologists use to explain the phenomena they are studying. There are several aspects of molecular biology that render it difficult to teach. Aside from being invisible, molecular biology is difficult to understand because there are several levels of organization that make the content complex and abstract. These were concerns that were shared by the teachers interviewed. They also expressed challenges in discovering an appropriate pedagogy that would engage the students and yet allow for effective content delivery. [47] suggest viewing animations and using interactive simulations to aid in students' understanding of abstract topics such as molecular biology. Such simulations can illustrate molecular interactions in terms of the random nature of collisions and the importance of direct binding and conformational changes.

In addition, teachers' content knowledge of molecular biology was also highlighted as a concern for some of the teachers interviewed. They felt insufficiently prepared for the teaching of complex molecular biology content due to their lack of training.

Currently, in the National Institute of Education, curriculum studies are essential courses aimed to help pre-service teachers learn how to teach. However, an assumption is made during the training for pre-service teachers. This assumption is that the pre-service science teachers possess current and adequate subject matter mastery since the pre-requisite for admission into the program is a first degree in the relevant field. Therefore, the specific content of physics, chemistry, and biology is not taught to pre-service teachers during their training in the National Institute of Education. This poses a challenge for biology teachers who have majored in a first degree that does not essentially involve molecular biology content. This challenge is reflected in the concerns of some of the teachers interviewed.

The lack of resources and support in curriculum implementation contribute to teachers' struggle in implementing a new curriculum. Many of the teachers interviewed shared challenges in incorporating the inquiry approach into their lessons. Teachers have been involved in curriculum design and planning. However, during curriculum implementation, teachers shared the sentiments of inadequate support. This results in the enacted curriculum not reflecting the intended curriculum. The implementation of the curriculum depends very much on the meanings teachers give to the curriculum or the curriculum changes. These meanings determine the manner in which the curriculum is implemented. Therefore it is essential that teachers give meaning to the curriculum changes.

## 6. IMPLICATIONS

This study provided the much-needed data to justify certain implications for the provision of quality teaching and learning of biology in Singapore as highlighted below.

- Development of an appropriately designed teacher training programme for the teaching of current content such as molecular genetics as well as training in the area of implementing formative assessment within the biology curriculum.

Biology teachers read different science majors in university, and some of them are not well equipped to teach the current topics such as molecular biology that have been recently introduced. Workshops and courses are provided by the Academy of Singapore Teachers as well as the National Institute of Education for in-service teachers. However, in-service teachers struggled to find the time to attend the courses and workshops planned for them. This resulted in them feeling insufficiently prepared for the teaching of the molecular biology topics. These workshops are also not scheduled on a regular basis and with a teacher's heavy workload, it becomes increasingly difficult to attend these courses or workshops.

In addition, formative assessment type questions have increased in appearance in the national examinations. Formative assessments are more open-ended and are considered to provide students with a platform to understand their weaknesses and strengths. There are some workshops or courses on the implementation of formative assessment. However once again, the teachers struggle with insufficient time to attend these workshops.

Teachers struggle to adapt to implementing new curriculum approaches when they do not have sufficient knowledge on the subject matter. In addition, teachers' interpretation and implementation of curriculum changes may not always be consistent with the intent and the expectations of the implementation body.

To address these concerns, there could be online options for these courses where the teachers are able to assess and acquire the knowledge required in their own time. It may not be an optimum approach, but it will allow the teachers some insights into the basic requirement of the teaching of the content or the expected outcome for the mode of assessment.

The conduct of the courses or workshops could be provided at the school premises. This would allow the teachers an easier access to the information. It would also minimize disruption to the teachers' classes. In managing these logistical constraints, teachers would acquire the required knowledge which allows for effective implementation in the classroom.

Further to this, recent biology content such as molecular biology could be taught during the teacher training programme. As mentioned earlier, science content is not explicitly covered in this programme due to the assumption that pre-service teachers would have acquired the first degree in science. If the content is taught during the teacher training programme, it may provide some foundation for beginning teachers in managing the content.

## 7. RECOMMENDATIONS FOR FURTHER RESEARCH

There are two areas where further research would be helpful –

1. Evidence from this study indicates a possible correlation between the implementation of a new approach in teaching and students' attitudes towards the approach. During the implementation of the inquiry approach, one of the concerns highlighted during the interviews with the teachers was the students' attitude and acceptance of the inquiry approach. The manner in which the students perceived the inquiry approach impeded the successful implementation of the approach. The correlation between teachers' attitudes, competencies, and perception of new approaches and the successful implementation of the approach has been extensively researched but not the students' perception in the same manner.
2. This study revealed a lack of research into the accurate implementation and effectiveness of formative assessment on the biology or science curriculum in secondary schools in Singapore. Formative assessment on its own has been extensively researched. However, there is a lack of research highlighting the implementation of formative assessment in the teaching of biology.

## 8. CONCLUSION

This chapter developed an understanding of the issues which are currently of concern to secondary school biology teachers and the perspectives they have regarding the curriculum of biology in Singapore. It provided insights to inform considerations for policy and further research, specifically in the teaching of secondary school biology, and the preparation and training of secondary school biology teachers. Data for this research question was collected using four semi-structured interviews at four randomly selected government secondary schools in Singapore. A total of twelve teachers were interviewed.

The teachers shared their concerns on the inclusion of molecular genetics and inquiry-based learning in the syllabus and the curriculum respectively. The findings from the interviews revealed that the teachers were concerned with the reduction of the classical biology topics in the syllabus. Some of them felt that the classical biology topics were essential for the understanding of biology as a subject. In addition, the teachers also expressed their struggles with incorporating inquiry-based learning in the curriculum. Their struggles revolved around their insufficient knowledge of inquiry-based approaches and the students' reluctance to participate in inquiry-based lessons.

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### Conflict of Interest

The author declares no conflict of interest.

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