Research in Social Sciences and Technology

https://ressat.org

E-ISSN: 2468-6891

Volume: 10 Issue: 1 2025

pp. 257-282

The Opportunities for Professional Growth When Using Knowledge of Students' Prior Science Ideas in the Teaching of Evolution and Genetics: A Self-Study

Tholani Tshuma[a] & Eunice Nyamupangedengu[b]

* Corresponding author
Email: ttshuma@wsu.ac.za

a. Department of Mathematics, Natural Sciences and Technology, Walter Sisulu University, Mthatha, South Africa.
b. University of the Witwatersrand, Wits School of Education, South Africa.

10.46303/ressat.2025.14

Article Info
Received: January 24, 2024
Accepted: May 14, 2024
Published: January 12, 2025

How to cite
Tshuma, T., & Nyamupangedengu, E. (2025). The Opportunities for Professional Growth When Using Knowledge of Students' Prior Science Ideas in the Teaching of Evolution and Genetics: A Self-Study. *Research in Social Sciences and Technology*, 10(1), 257-282.

https://doi.org/10.46303/ressat.2025.14

ABSTRACT

This inquiry sought to investigate the opportunities and potential challenges of engaging in a self-study approach as a strategy for enhancing professional growth during my teaching of the topic of evolutionary genetics to 24 twelfth-grade students. I had, for many years, experienced pedagogical deficits and shortcomings when teaching evolutionary genetics despite my professional knowledge from my teacher training. I always struggled to a) represent this content in ways that make it comprehensible to my students, b) motivate my students to accept this topic, and c) address students' misconceptions. Vygotsky's social constructivism of knowledge and the idea of pedagogical reasoning and action as propounded by Shulman were the key theoretical lenses that guided this inquiry. Collected data included pre- and post-intervention data, students' conceptions of evolutionary genetics ideas, lesson transcripts, my reflections, pedagogical actions and reasoning during my teaching, and notes on collaborative activities with critical friends. The collected data was analysed from a quantitative and qualitative approach. Thematic analysis for emerging themes was done from a deductive to inductive data analysis approach. This study established that through the idea of opening up for professional feedback from critical friends, one ought to make one's pedagogical reasoning and actions public. This opening up makes one 'vulnerable' to severe criticism or 'attack' by critical friends. However, despite this setback, it offers unlimited professional growth opportunities beyond one's personal biases, interpretations, and teacher training expertise on key issues of practice. The 'negative' and positive critiques from others are powerful critical reflection points for enhancing professional development. However, through engaging in open feedback collaborative sessions, a practitioner experiences internal tensions between the 'inner egoistic voice' and the probing 'outer voice'. Thus, the ability to objectively reconcile one's inner voices in the wake of the usually unfriendly outer voices is a crucial starting point for one to realise professional growth as a practitioner.

KEYWORDS

Professional development; self-study; evolutionary genetics life-long learning.

INTRODUCTION

This inquiry sought to investigate the possible opportunities for enhancing professional growth that can arise from using knowledge of students' prior ideas and self-study approach to inform my teaching of evolution and genetics to 24 twelfth-grade students. I had, for many years, experienced pedagogical deficits and shortcomings when teaching the topics of genetics and evolution despite my professional knowledge from my teacher training. I always struggled to a) represent the content of these topics in ways that make it comprehensible to my students, b) motivate my students to accept the topic of evolution, and c) address students' misconceptions. As teachers, we are always encouraged to engage in life-long learning (e.g. Gordon, 2011) because we are perceived to be life-long- learners (Tshuma, 2023). However, what is not always indicated is how this lifelong learning should unfold and the framework that assists teachers in this regard have hardly been explored. Scholars such as Knowles (1975) put forth the idea of self-directed learning, but arguably, this is more about the will to do something and falls short when it comes to the modalities of doing it. The quest of this inquiry is to contribute towards filling that research gap because '… *teacher learning and the investigation of factors contributing to teachers' professional development is of high importance'* (Krolak-Schwerdt & Glock, 2014, p. 3).

My teaching (of which I had become dissatisfied) had been characterised by what I came to describe as a 'traditional pedagogical style' which was dominated by 'chalkboard, textbook and talk'. Whilst it could be argued that such traditional teaching practices have been tried and tested, I felt professionally handicapped in my attempts to teach evolution and genetics to my students. This is because my teacher training expertise was failing me to teach these topics for comprehension, motivation and conceptual change. In my quest to improve my teaching of these topics, I engaged in self-directed learning through self-study which is a type of practitioner research in which the researcher is also the subject of investigation. As indicated by Nyamupangedengu (2023), self-study is carried out by practitioners seeking to gain a deeper understanding of and enhance their professional practice. It is usually motivated by the practitioners' own experiences, often stemming from the challenges, frustrations, and dilemmas encountered in their practice. A fundamental underlying question of self-study research is "How can I improve what I am doing?" Guiding this inquiry was, therefore, the following research questions:

What opportunities for professional growth are provided when using the knowledge of students' prior science ideas and self-study to inform the teaching of evolution and genetics topics? What challenges (if any), are faced when using self-study for professional growth?

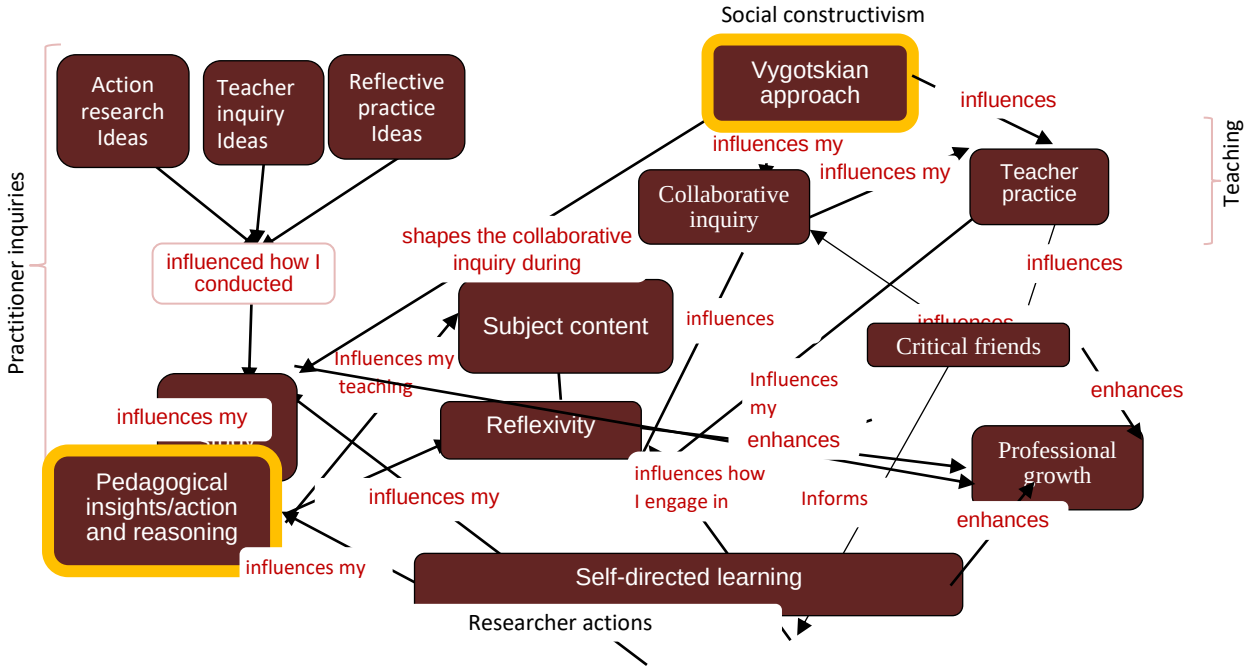
Literature review and conceptual framework for the study

Each piece of research that involves human subjects is complex and unique (Yin, 2011). Based on this premise, finding a single existing framework for use in this typical social sciences inquiry was difficult. Thus, a '*personal integration of concepts or home-grown framework'* was used instead of using a single already existing theory *or 'off-the-shelf'* theoretical framework

(Antonenko, 2014, p. 3). In this inquiry, I used the notion of a conceptual framework *"…as a visual representation of the structure of the study and its alignment with the relevant theoretical foundations. According to this view, a conceptual framework is a figure, typically presented as a concept map that summarizes all key information presented in the literature review of the study"* (Antoneko, 2014, p. 3). Figure 1 below therefore, represents the conceptual framework for this study.

Figure 1.

The Conceptual framework for the study



The various concepts depicted in Figure 1 above are explained below

Self-study

As indicated earlier, self-study is a type of practitioner research in which the practitioner, who in this research is the teacher, is also the researcher and the subject of investigation. Several tenets typify self-study. Below, I describe tenets that explain and describe what a self-study entails. The first tenet is that self-study is a "**personal situated inquiry**" because it arises from the individual teacher's daily work activities as they teach (Samaras, 2011). In this regard, the '… self is intimately involved and entangled in the inquiry' (Pinnegar & Hamilton, 2011, p. 346). In this study the investigation came about from my work due to the dissatisfactions I faced during my teaching of evolutionary genetics to grade 12 learners. The second tenet is that self-study is a **"Critical collaborative inquiry**" because teachers mutually get involved in an investigation as researchers on issues aligned to their workspace (Kaser & Halbert, 2014). Such inquiries become critical when new insights emerge from the researchers' reflections in the light of critical feedback from critical friends because ideas that inform practice add to the teaching body of knowledge (Samaras, 2011). Feedback from critical friends is a crucial validation tool.

The third tenet is that self-studies result in **"Improved learning"** for those who partake in it *(Samaras, 2011).* For instance, **t**hrough conducting self-studies, practitioners tend to gain professional knowledge for practice (Glennie & Cosier, 1994). This gained knowledge is crucial as it also helps to '… *understand and improve teachers' work as professionals, impact students' learning, inform education and school programs, influence policy decisions, and reform education*" (Samaras, 2011, p. 11). The last tenet is that in a self-study, there are no secrets or hidden agendas (Samaras, 2011). Thus, a self-study is a "… **transparent and systematic research process".** A typical self-study does not involve any hidden agendas as it"… is a transparent and systematic research process requiring an open, honest, and clear description of the spiral of questioning, framing, revisiting of data, and reframing of a researcher's interpretations" (Samaras, 2011, p. 11). This is because when doing a self-study, researchers open up their views and thinking for critical feedback from critical friends or colleagues (Pinnegar, 1998).

Teacher inquiry

Since the 1970s, when 'experts' would do research on teachers as passive respondents and then inform them about the outcome, there has been a change in the way research on teachers is being done (e.g., Borko, 1979). The changes involve now including teachers in the research about their practice as active participants in knowledge production (Clark & Yinger, 1979). Thus, this change from having teachers taking the role of being consumers of knowledge to the role of active producers of that knowledge on in practice implies that "… *teacher research gained new standing because of its potential to lessen the divide between theory and practice, on the one hand, and contribute needed insider perspective to the knowledge base about teaching and learning*" (Cochran-Smith & Lytle, 2004, p. 603). In this investigation, these insights were crucial for me to realise the need to engage in this self-study about my practice, and investigate the dissatisfactions arising from my practice, rather than wait for 'experts,' to tell me what was wrong with it.

Reflective practice

According to Loughran and Northfield, (1998, p. 15) and as viewed in this inquiry, reflection is '*… a personal process of thinking, refining, reframing and developing actions*'. In this study, because reflection takes centre stage in steering the direction of professional growth, I set out to use reflexivity as a key process of shaping and informing practice. Thus, the notion of thinking about thinking or what other scholars (e.g. Flavell, 1979), describe as metacognition, was important for generating insights for thinking about and understanding my practice.

Action research

Action research has the thrust of solving work-related professional challenges/problems (Samaras, 2011) as it is '… *disciplined process of inquiry conducted by and for those taking the action. The primary reason for engaging in action research is to assist the 'actor' in improving and/or refining his or her actions*' (Sagor, 2000, p. 7). Thus, when compared to a self-study, while a self-study is underpinned by the 'self', action research places emphasis on workplace problems and changes (Samaras, 2011). In addition to this, a self-study does not necessarily focus on

providing solutions to professional problematic issues, but even on understanding why issues are problematic for possible solutions later (Samaras, 2011).

Critical friends

Self-studies are not about the self and for the self, only, but they include what are termed critical friends (Samaras, 2011). The issue of Critical friends in a self-study inquiry is crucial as these help with issues of validation of the findings. Critical friends are scholars who understand and appreciate the value of a self-study inquiry to themselves, the self-study scholar and the body of knowledge being contributed to by the inquiry in a quest to improve practice (Shuck & Russell, 2006). They play a crucial role in validating results by critically probing the self-study researcher to view issues beyond his/her limitations and bias. In this study, in a bid to bring in divergent views, the second author played the role of a critical friend.

The content of genetics and evolution

In my bid to select the content for teaching, I summarised all the evolutionary and genetics-related topics taught in the South African schools from Grade R (kindergarten) to Grade 12. This was done following what was presumed to constitute 'evolutionary genetics' ideas.

Two biology experts (PhD holders in biology) were then asked to validate if the selected content was a sound representation of what is in the syllabi. The rationale for this was to maximise the idea of not leaving evolution-related concepts, and also not to include irrelevant syllabus details. After cycles of face validation. The final topics selected for teaching included (not in order of how they could have been taught: genes, chromosomes, DNA, alleles, sources of variations (mutations, segregation, and independent assortment), variations in organisms, inheritance, speciation, and mechanisms of evolution (genetic drift; natural selection,), evidence for evolution, human evolution, the idea of evolution and religion, Lamarckian ideas and. Darwinian views.

Self-directed learning

This self-study has notions of 'self-directed learning' as postulated by scholars such as Knowles (1975). This is because during self-directed learning, self-study scholars engage in the process:

> *… in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.* (Knowles, 1975, p. 18).

The rationale for my conducting this self-study was for me to take the initiative to be a *proactive learner on professional issues*. This is because research shows that proactive practitioner learners 'tend *to retain and make use of what they learn better and longer than do the reactive learners*.' (Knowles, 1975, p. 14).

Social constructivism

The theory of social constructivism guided this study. The basic premise of socio-cultural theory is that social interactions are crucial for learning and cognitive growth. This is because every individual's *"… cultural development appears twice: first, on the social level, and later, on the*

individual level; first, between people (inter-psychological) and then inside" (Vygotsky, 1978, p. 57). Thus, one of the pre-conditions happens to be that individuals ought to be actively engaged, not as individuals, but in the company of the more knowledgeable others (Vygotsky, 1978). In this investigation, the role of the more knowledgeable others was *"… to provide the setting, pose challenges and offer the support …"* for new knowledge generation (Davis, 1990, p. 3). Thus, the knowledgeable others helped me learn about professional issues beyond my zone of proximal teacher development [ZPTD] because, during professional learning about teaching, one can learn and even professionally grow in the company of the more informed others (Vygotsky, 1978).

Pedagogical reasoning and action

The construct of pedagogical reasoning and action was chosen in this study to guide my teaching. This followed ideas by Shulman (1987). The construct has the following stages: comprehension, transformation (which in turn has four phases), instruction, evaluation, reflection and new comprehension. These stages happen in cycles which involve comprehension of content for teaching which in this case was the content of evolution and genetics topics. To have a good grasp of this content, I had to review literature on the topic of evolution, how evolution occurs and the evidence of evolution evident around us. The comprehension of content was followed by transformation which involves preparation of the content for teaching which included selecting instructional repertoire and representations and adapting these to students' characteristics (The transformation of content was followed by instruction, my evaluation of the effectiveness of my teaching strategies (*evaluation*); my reflections on the weaknesses and strengths of my teaching strategies in the light of critical feedback from my critical friends (*reflection*); and learning from insights that emerged from the more informed other [*new comprehensions*] (Shulman, 1987).

The notion of professional development

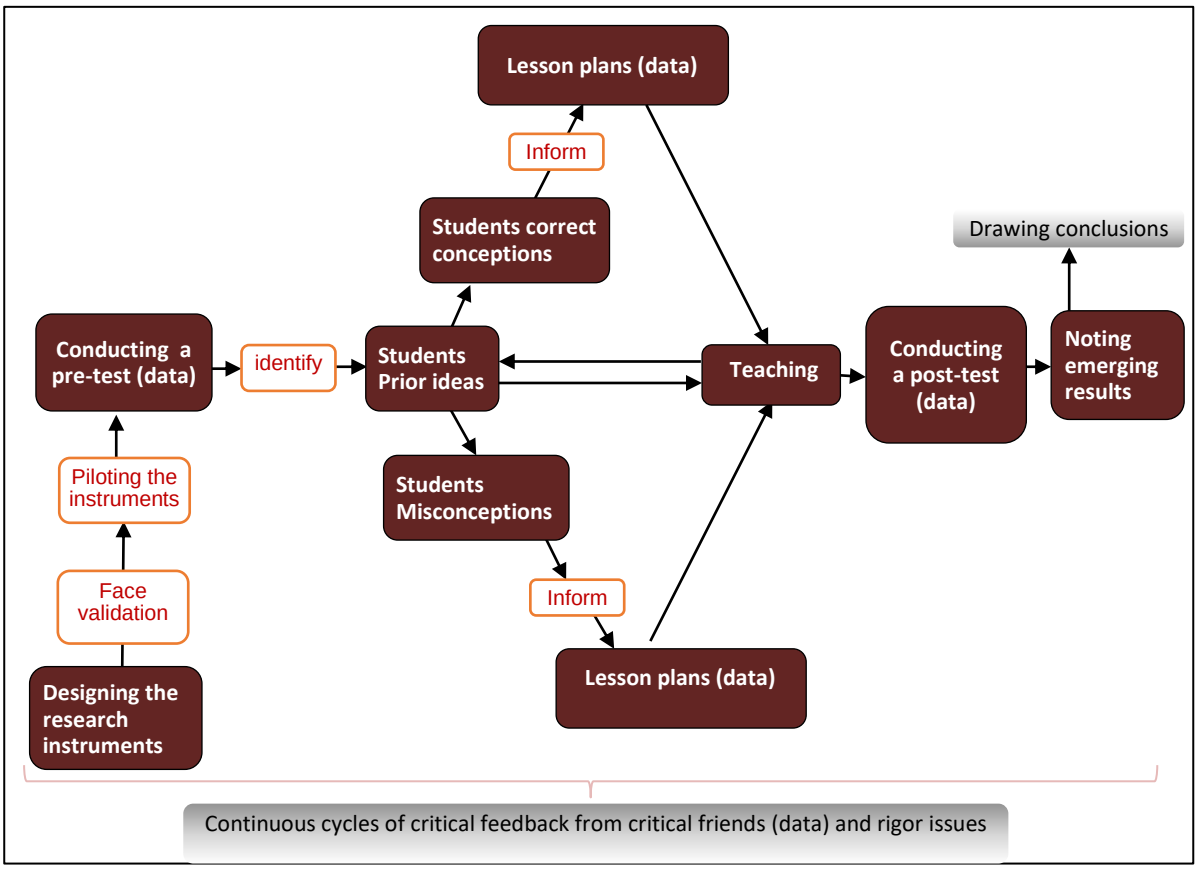
Scholars such as Klingner (2004) articulate the notion of professional development in terms of teachers' professional learning of new practices. In this inquiry, professional growth/development is used to refer to the acquisition of pedagogical skills, knowledge, expertise and other traits that distinguish a novice from an expert teacher when teaching a specific topic.

METHODOLOGY

This study was a mixed-methods self-study inquiry in which quantitative data, in the form of pre-test scores, was first collected, followed by qualitative data. Figure 3 below shows the methodological steps that were followed in this inquiry**.**

Figure 2.

Methodological steps followed in this inquiry



Participants

This study was a self-study; thus, I was both the central focus of the research and the researcher. The other participants were my 24 Grade 12 Life Sciences students at a religious high school in Johannesburg. The grade 12 learners became participants by virtue of being learners in a grade 12 class in which I was responsible for teaching the topics of evolution and genetics.

Data collection

As can be seen in Figure 2, data was collected using multiple methods in this inquiry. Sources of data included pre- and post-tests of students' ideas about evolution and genetics, lesson plans and teaching transcripts, journal entries of my thoughts and reflections before, during, and after my teaching, and audio recordings of discussions with my critical friend (CF).

Pre-and post-testing

A pre-test identified the students' prior ideas. Post-testing tracked the students' conceptions of evolution and genetics concepts after my teaching. Therefore, the same test instrument was used.

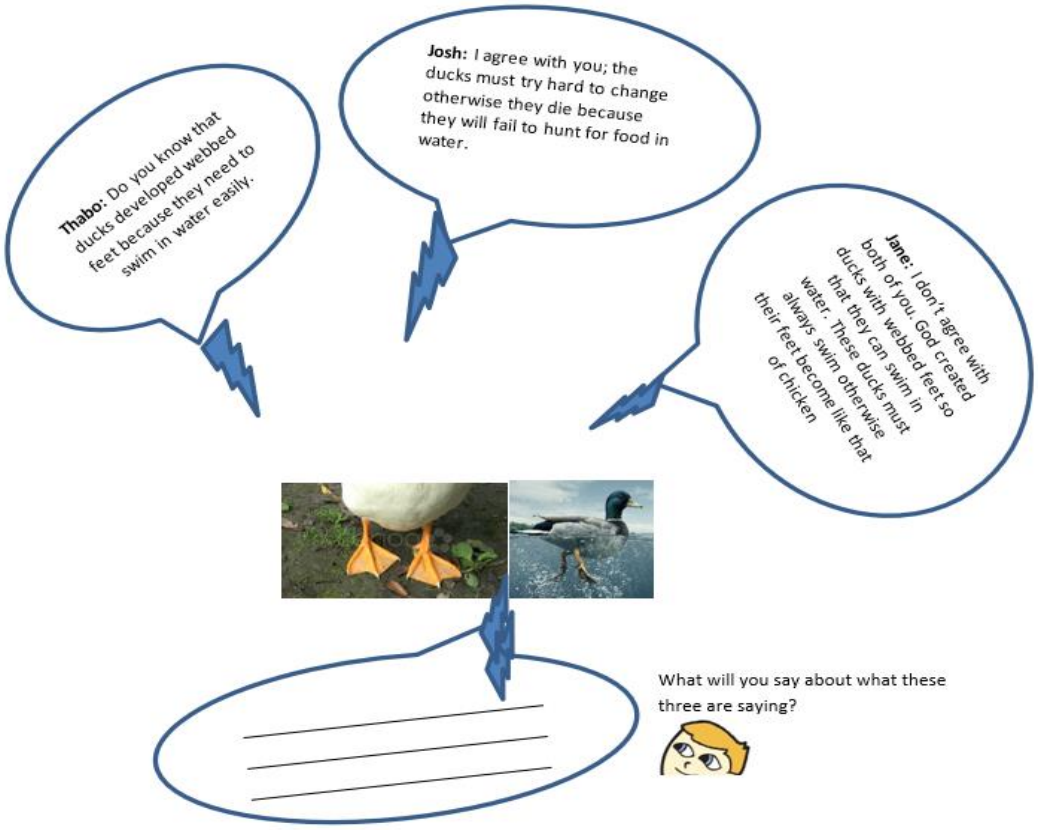
Structure of the pre-/post test

The test instrument consisted of statements constructed around known misconceptions about evolution and genetic concepts. This instrument is shown in Figure 6 below, which also shows

the results/students' responses. Part of the pre-test also included contextual situations that tested the students' conceptions of evolution and genetics (see, for example, Figure 3 below).

Figure 3.

Soliciting students' conceptions of evolution using talking heads



Students' responses were captured in the speech bubble for this particular question on the instrument.

Administration of the pre-test

On the first day of the study, the research was explained to the students. Consent forms were completed, after which the pre-test was administered. The students were asked to say if the statements provided in the instruments were correct or incorrect and give a reason for their choice.

Journaling

Journaling entailed the systematic recording in a journal/notebook of my reflections and insights throughout the entire study. The rationale for this was to keep a permanent record of my pedagogical actions, reflections and reasoning.

Planning and teaching

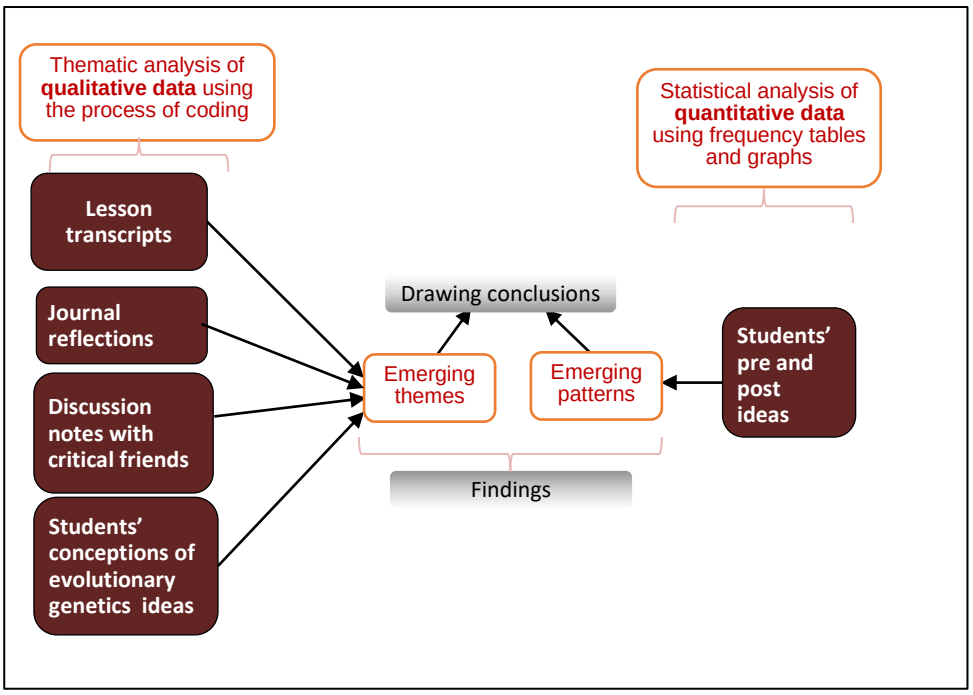
Planning and teaching were informed by the students' identified prior ideas i.e. the conceptions and misconceptions identified from the analysis of the pre-test. This approach was motivated my quest to teach for enhanced student comprehension. Four lessons spanning 2 hours each were planned for teaching what at this point was now evolutionary genetics content. In order not to interfere with the normal teaching timetable, the teaching which was part of the data collection in this study was done during weekends to the Grade 12 students.

Data analysis

The data that was collected in this study was analysed following the steps depicted in Figure 4 below. The pre and post-test responses were analysed both quantitatively and qualitatively. The lesson transcripts and discussions with critical friends were thematically analysed for themes using the process of coding.

Figure 4.

Steps followed in analysing the data that was collected in this study



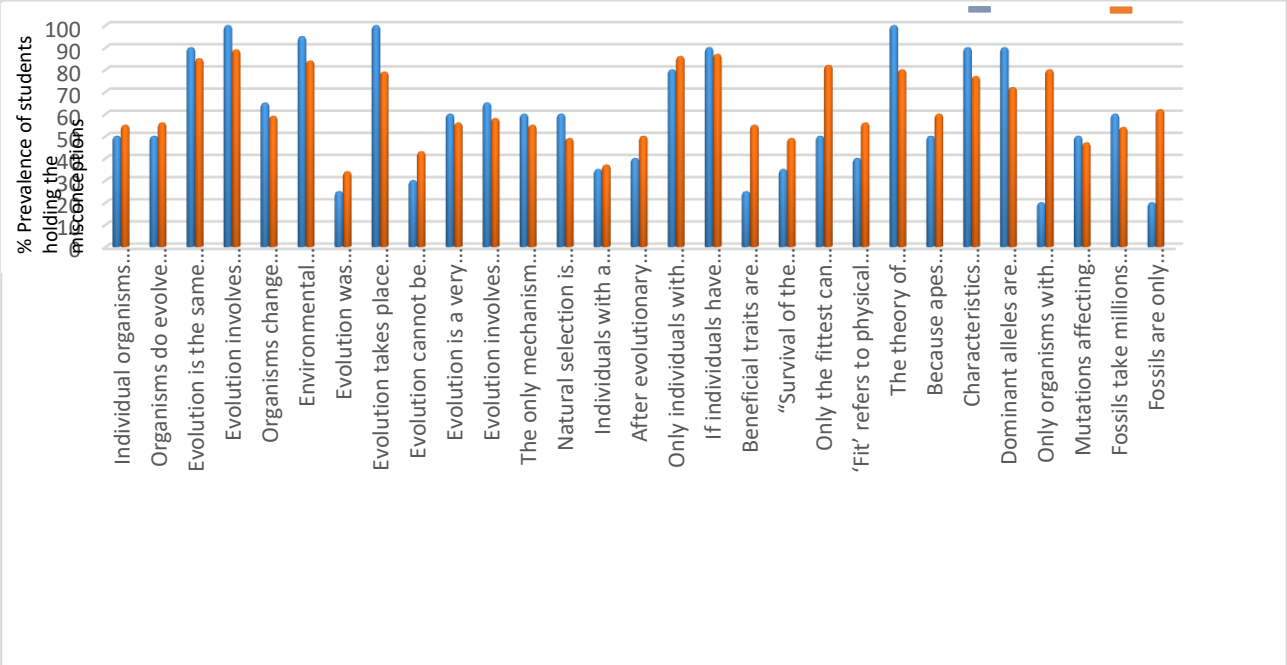
Analysis of the pre- and post-test responses

Quantitative analysis

I read through every student's script recording on a spreadsheet, whether a student's response was a yes or a no to each statement. After going through all the scripts, the number of students holding a particular misconception were then counted and the figures obtained were used to calculate the percentage prevalence of each specific misconception (see Figure 6).

Figure 6.

Misconception aligned to little understanding of how evolution happens (mechanisms of evolution). Student pretest ideas Textbook ideas



These identified misconceptions were then clustered into four main themes that are presented in Table 1 below.

Table 1.

Typologies of students' evolution misconceptions

Category of misconceptions	**Total identified across all students (N=24)**
Misconception aligned with little **understanding of how evolution happens (mechanisms of evolution)**.	24
Misconceptions aligned with one's religious beliefs	13
Misconceptions aligned with little **understanding** of ideas about the nature of science	13
Misconceptions aligned with little general knowledge of evolution and genetics	12

Qualitative analysis

Qualitative data was coded. The following is a coded statement from a student's response to the task in Figure 3 in section 3.2.1.1 which was based on a dialogue between three friends who were talking about the webbed feet of a duck. Jack: *I agree with all of you, ducks have and develop webbed feet so that they swim* **[organisms evolve during their lifetime],** *because without such feet, then they will die of hunger, as they cannot catch fish* **[organisms evolve**

purposefully for a reason]. *God created ducks with webbed feet for a purpose of swimming easily* **[Use of creationist ideas to explain science]**.

Below is an excerpt showing lesson transcript coding

- **Teacher**: *Do you know that we have also been evolving and we are no longer the way we looked 2.3 million years ago?* ***TQ: T****eachers ask* ***Q****uestions*
- **Students' response:** *chorus uproar, showing open interest.* **IS:** showing openness/**I**nterest to learn
- **Jane:** How do you know about that? Were you there? **IS/SQ: S**tudent's **Q**uestioning revealing an underlying interest to learn/negative view about the topic
- **Jack:** Evolution is just a theory. **SE: S**tudents' **E**rroneous thinking
- **Teacher** comment: *Somebody is saying that evolution is just a theory; can you explain what you mean by that?* ***TQ: T****eachers ask* ***Q****uestions to invoke further learning*
- **Jack:** *Evolution has not been proved; it is like a story imagined by scientists* **SE: S**tudents' **E**rroneous thinking

Teacher comment: *Have you ever wondered what religion says and what scientists say?* ***TQ: T****eachers ask* ***Q****uestions to invoke further learning*

Note that in this study, data collection and analysis was not a linear process but heumenitic (Nyamupanedengu, 2024). For example, the post-test data was collected and analysed, which informed the collection of more data in the form of lesson plans. During lesson planning, I continued to revisit, discuss with critical friends and reflect on students' responses for further insights. The lesson plan led to more data collection in the form of teaching observations. After every lesson, I will share, discuss and reflect on the observations with a critical friend which would entail revisiting the pre-test results and the lesson plans.

How rigour issues were addressed in this study

Validation of the test: In a bid to uphold the validity of the research findings, the instruments that were used in this study were designed following cycles of face validation which involved experts (PhD holders) in science education (see Figure 2). Prominent scholars such as Miles and Huberman (1994) recommend that to maximise rigour, the instruments used ought to be face-validated. Face-validation refers to common truth (Krippendorff, 2013) or the "… extent to which an instrument looks as if it measures what it is intended to measure" (Patton, 1996, p. 253), according to expert opinion or judgment. The face-validation in this study involved drafting the instruments and then allowing critical friends and experts in the field to critique them in open discussions. The comments raised were used to update the instruments. The test instrument was piloted. This involved trying out the instruments on a small-scale study before the main study (Creswell, 2012). In this investigation, the test was tried out involving 3 students and all problematic issues with the instruments that were picked were rectified before the main study.

***Continuous critical feedback from critical friends*:** The critical friends assisted in critiquing all the steps taken by the researcher. This assisted in probing my viewing of research issues beyond my individual biases and capabilities.

FINDINGS AND DISCUSSION

This study was guided by the following questions: *What opportunities for professional growth[1] are provided when using the knowledge of students' prior science ideas to inform the teaching of evolutionary genetics through self-study? What benefits are gained, or challenges faced (if any), when using self-study for professional growth?*

The analysis of students' responses to the pre-test revealed that students held many misconceptions about evolutionary genetics. Figure 6 below shows students' misconceptions. The analysis of the journal entries (pedagogical reasoning entries and reflections), discussions with critical friend and lesson transcripts revealed the following six themes:

- Identifying and using learner misconceptions to inform one's teaching is a professional development activity.
- The negative and positive critique from others are powerful **critical reflection points** for enhancing professional growth.
- Students' held misconceptions that mirror those in the textbooks they use are a challenge to the teacher that could be redressed through the refutation techniques
- Making public one's teaching challenges offers professional growth opportunities.
- Teaching in ways that uphold the students' diverse preferred learning styles facilitates conceptual change and redress some held misconceptions.
- Curriculum content delivery is not just about following the way topics are sequenced in the syllabus documents, but it calls for rethinking and probing so that it becomes tailor made for maximising comprehension for each specific and unique group of students
- Making public one's teaching challenges makes one vulnerable.

Below, I use the themes as sub-headings to discuss the findings

Theme 1: Identifying and using learner misconceptions to inform one's teaching is a professional development activity.

Before engaging in this study my teaching was "blind" i.e. it was not informed my anything. I would just prepare the content on genetics and evolution and teach. By using pre-testing, I was able to identify the prior conceptions including misconceptions that my students were bringing to class which enabled me to think through and to pedagogically reason with the help of my critical friends about the most effective ways of dealing with the misconceptions. For example, I came up with a technique that I have coined the **refutation technique.** This involves the use of 'refutation texts' to address misconceptions held by the students in the context of those in the

[1] Professional growth/development is used to refer to the acquisition of pedagogical skills, knowledge, expertise and other traits that distinguish a novice from an expert teacher when teaching a specific topic.

textbooks they use. In this study, the refutation texts were designed from scratch to meet the unique dictates of this inquiry. Below is an example *of a creationist refutation text that I used in response to the following misconceptions which were held by students: Human beings were created by God as stated in the Bible:*

> *The general religious belief is that human beings were created by some form of a Supreme being. However, the use of religious explanation in terms of the origin of life is not the same as the scientific view. According to the scientific view, the diversity of life, including human evolution, is best explained through Darwin's theory of evolution by natural selection. This has the notion of descent with modification. Science does not agree with biblical notion in the Book of Genesis 1 verse 2 that says humans were created from simple clay*.

The use of refutation techniques made the redressing of students' ideas through a text-based storyline much easy to use and follow as a comprehension text. Seemingly, this technique help achieve two things at the same time. These include the learning of the content and rectification of the misconceptions. Thus, these two complemented each other in simplifying the way I taught for student comprehension.

By pre-testing and identifying students' misconceptions and then plan teaching and learning activities targeting the eradication of these misconceptions, I became aware of the misconceptions which are easy and those that are difficult redress. I learnt that students' misconceptions can be grouped in categories: namely **acquired errors category and rooted or entrenched** misconceptions category. Acquired errors/misconceptions seemed to arise probably because students had not been exposed to the correct science. Examples of such misconceptions are fossils are only found in rocks, and the idea that evolution only happen over millions of years, these changed after my teaching. The **rooted** or **entrenched misconceptions** were those over 95% of my students retained even after my intervention teaching. Table 2 below shows examples of these misconceptions.

Table 2.

Rooted students' misconceptions

Misconception	Pretest: % of students	Post-test: % of students
There is a Supreme being that controls evolution by natural selection	80	78
A Supreme being created human beings	80	77
Evolution occurs when organisms try to adapt to survive	100	98

As can be seen in Table 1 above, rooted or entrenched misconceptions are those entrenched in the students' lives, e.g. those aligned to how evolution occurs (***mechanisms of evolution)*** and **creationist beliefs**. For example, the misconception *that 'Evolution is about organisms consciously making efforts to adapt to survive'* emerged as entrenched because it

turned out to be linked to children's naïve theories of thinking that organisms evolve to avoid dying (e.g. Mead, 2017). Other studies have revealed that naïve theories are problematic because they often persist well into adulthood, cause hosts of misconceptions that are often at odds with evolution ideas (e.g. Mead, 2017).

Theme 2: The negative and positive critique from others are powerful critical reflection points for enhancing professional growth.

Through cycles of collaboration with my critical friends, I came to a new understanding of how to promote student understanding. For example, from identifying students' misconceptions in my teaching, I learn the following: 1) how to enhance student conceptual change from entrenched misconceptions. I learnt that because entrenched misconceptions are difficult to eradicate, they may need long-term strategies, as they are difficult to redress through one or two lessons. 2), that sound knowledge of specific misconceptions held by students is important in order to enact **refutation pedagogical strategies** that are tailor-made for enhancing conceptual changes from those identified misconceptions and 3) that by categorising the students' misconceptions as **acquired errors** or **entrenched** I became aware of some of things to consider when planning to redress acquired errors and what to consider when dealing with entrenched misconceptions.

In my quest to further understand the nature and scope of the above categories of students' misconceptions, I compared them with what I had found in their textbook in another separate study (Tshuma, 2016). It was a notable challenge that the misconceptions held by my students were the same as those unveiled in their textbooks [see Figure 6 above for this comparison]. Reflections in the wake of critique and comments from others were used throughout the entire study to determine the teaching strategies for use, the choice of content for teaching; results analysis and drawing of conclusions. On the issue of having to teach students whose erroneous ideas mirrored those in their textbooks, a critical friend commented (code used is in square brackets):

CRF 1: *Now that you are aware that the students thinking patterns mirror those in their textbooks, what next?* **[Critical feedback on pedagogy]**

After this question, as I was not sure of what to do, I interacted with a colleague, critical friend and a science education expert. They probed me and this led me to coming up with what I have coined **refutation technique.** This involved the use of 'refutation texts' to address misconceptions held by the students in the context of text extracts in the textbooks they use. This approach redressed some of the students held misconceptions.

Theme 3: Students' held misconceptions that mirror those in the textbooks they use are a challenge to the teacher that could be redressed through the refutation techniques

Furthermore, through engagement with critical friends and reflecting on my teaching, I also learnt how to a) cater for my students' preferred learning styles, b) simplify abstract concepts and c) motivate students thereby showing that ***making public one's teaching challenges offers professional growth opportunities (Theme 4)***. I provide examples of this third category below.

A: Visual students: One key aspect of my dilemma was that my students were struggling to comprehend the microscopic aspects of genetics. Other studies (e.g. Shulman*, &* Calabi, 2012; Mead et al., 2017) point out challenges students encounter when learning genetics and evolution, but such studies do not provide possible hints on how the teacher could overcome such challenges. In this study, static content representations involving pictures, smart board visuals, and DNA thread models made from everyday materials like paper and string were used to simplify and demystify the notion that genetics is difficult and not linked to the student's everyday lives. The simulation practical (Figure 7 below) and animated audio-visuals (dynamic content representations) were used to address the misconception that evolutionary genetics is just a proposition which is yet to be verified. The students could see the animated videos that showed evidence of evolution and how it happens. Models were also used to concretise abstract ideas such as DNA, genes, nucleotides and hydrogen bonds.

Furthermore, through **dynamic** content representations e.g. the use of animated audio-visuals, this also addressed students' common misconceptions. For example, a student (Jack) had the erroneous thinking that reproduction and evolution are synonymous**:**

Jack: *My thinking is that the white rabbit reproduces with the black rabbit.*

The animated audio-visuals involving the changes in population from white rabbits to brown rabbits only in brown background and vice versa in white background simplified my addressing of the difference between reproduction and evolution (See Figure 5 below).

Figure 5.

Animated visuals showing a population of white rabbits evolving into a brown population.

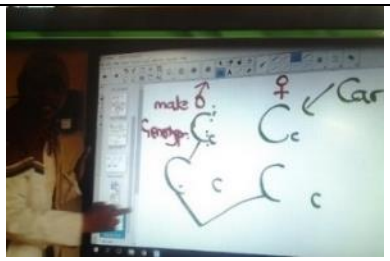
Kinaesthetic students: My challenges also centred on teaching abstract ideas. Elsewhere, both the students and their teachers have been found to struggle to grasp pertinent details about **evolution by natural selection** (e.g. Mead, 2017) because it is a complex metaphor**,** and no possible pedagogical hints for teachers have been offered. In this study, 'The Black Goggle Simulation Experiment', animated audio-visuals and analogues were used to show evolution by natural selection. During the simulation experiment, one student used a pair of pincers to pick

beads within a period of 30 seconds. This was repeated six times to represent six generations. The different coloured beads that remained in a given environment were then counted and doubled. The beads population evolved from white colour to black beads in a camouflaged background and vice versa. Because the individual beads did not change, this offered me an opportunity to address common misconceptions that *organisms evolve during their lifetime.*

Mathematical or logical students: Figure 6 shows how the idea of genetic crossing was taught through the smart board multi-colour writing to cater for the logical students.

Figure 6.

Teaching in ways that cater for mathematical students

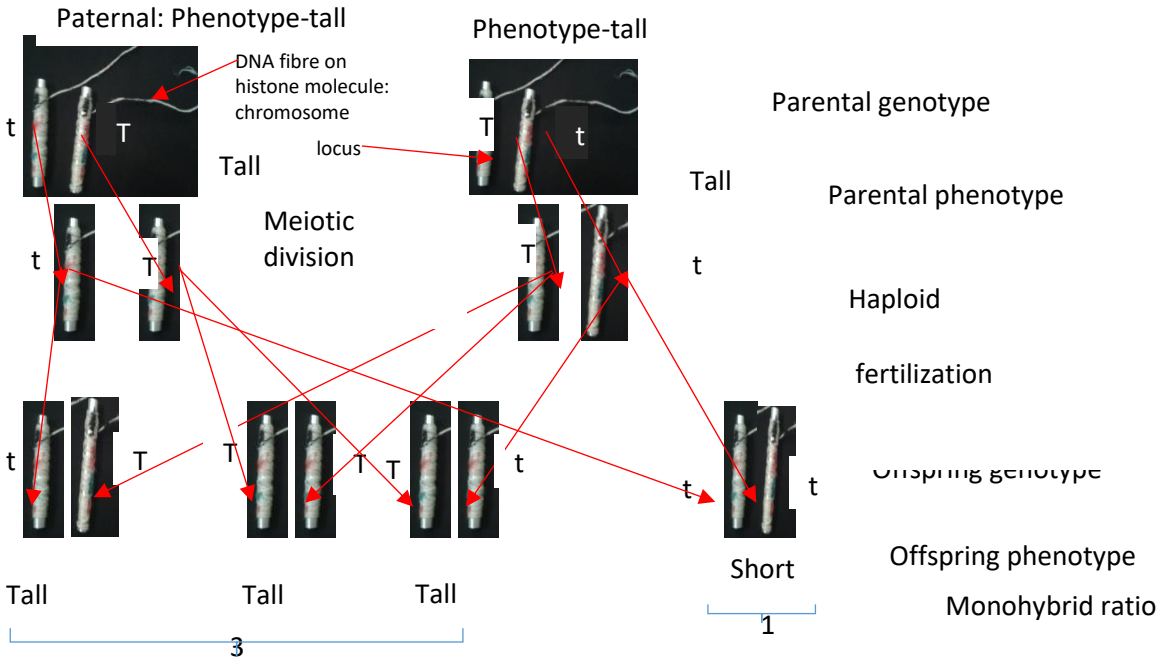
Mathematical students	 **Teacher**: *What happens when normal parents produce an albino?* **Students:** *All normal.* **Teacher** uses the analogue of mixing sugar and salt to explain the inheritance of dominant and recessive alleles for a given inheritable trait, and genetic puzzles to solve using a simulation experiment.

As evident in Figure 11 below, the pre-test results showed that most of my students struggled to understand genetics ideas at a symbolic or mathematical level, e.g. monohybrid ratio. This corroborates findings by scholars such as Mead, (2017). Analysis of my teaching also showed that I catered for the students' whose preferred learning style is mathematical/logical when I provided inheritance 3 to 1 puzzles for the students to solve. An analogue of sugar ('recessive') and salt ('dominant') giving a salty taste (heterozygous) was used to explain these genetic terms. The idea of a genetic cross was done in the form of a practical as shown in Figure 7.

Simulation of complex meiotic processes using simple scrap materials found in the students' lives turned out to be an effective way to simplify how I taught, provided the students hands-on learning, and also enhanced students' learning and understanding of the relationships between different terms. The simulation practical turned out to be suitable for the kinesthetic students.

Figure 7.

Monohybrid simulation (Source: Tshuma, 2020)



Solitary or intrapersonal students: Prior to this study, my classroom challenges also entailed my inability to make my teaching appealing to the students I taught. The use of 'flipped classroom' which involved the students doing their 'homework' at school as classwork' (see lesson excerpt below) and then learning everything at home via animated instructional videos lessons uploaded on their tablets (see Figure 8 below). This turned out to be appealing to my students' interest to learn, especially the intrapersonal students, e.g.:

Jane: *May you upload on our tablets that video on hominids?*

Class/ Student*s: Yes, that one.*

My pedagogical reasoning to use the idea of a 'flipped classroom' arose after noticing that students spend most of their free time using their tablet/phone. This teaching approach turned out to deviate from the usual scenario of having students sitting behind their desks and the teacher standing in front type of 'schooling approach' and is thus an important new teacher knowledge domain for the twenty-first century. I coined the phrase '**knowledge of flipped cyber schooling'** for this teacher knowledge domain.

Auditory-musical students: My classroom challenge also entailed challenges I faced in having my students comprehend complex terminology. In this study, Hip Hop Education and animated audio-visuals were found to motivate students (see Figure 9), simplify the way I teach, and bring delight to their learning of usually perceived abstract evolutionary genetics ideas. For instance: **(Maria):** *learning through music is fun*, is an indication that music-infused content turned out to be enjoyable, less difficult, and less stressful. Furthermore, the repetitive rhythms of hip-hop music assisted students in mastering difficult terminology, e.g. the DNA base pairing in the

lesson excerpt below. The use of music also resulted in improved class attendance and punctuality, which used to be problematic during my traditional teaching.

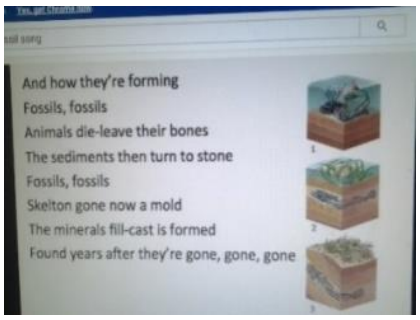
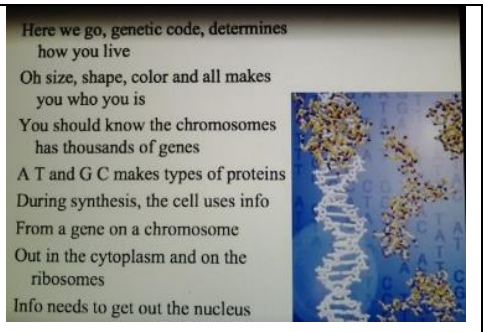
Figure 8.

Teaching for solitary learners

Solitary learners	 **Teacher** transfers educational videos to the students from the smart board to their tablets for home learning.

Figure 9.

Teaching for auditory-musical learners

Auditory-musical learners	  **Teacher** *You are going to watch a biology hip pop music as used in biology in generally and then I will show you more songs to learn about human evolution, which you learnt about in the Social Sciences and in one of the Grade 12 previous lesson you learnt, i.e. evolutionary genetics.* **Students***: clapped hands after the song* **Maria***: Learning through music is fun*.

As can be seen in the presented teaching and learning activities above, I learnt many ways of catering for my students' learning styles and it emerged that when teaching in ways that cater for students' diverse learning styles, students' understanding is not only enhanced but also held misconceptions are addressed (***Theme 5: Teaching in ways that uphold the students' diverse preferred learning styles facilitates conceptual change and redress some held misconceptions***).

Other professional development opportunities included developing a pedagogically reasoned out unit for teaching that I called evolutionary genetics (see earlier section…). After opening up on my pedagogical actions and reasoning when teaching evolutionary genetics, my critical friends probed me into further reflections as to how I had been teaching these topics. I then realised I taught these topics as separate entities because the syllabus stipulates that

genetics be taught in term 1 and evolution be taught in term 4. I realised the need to teach these topics as a single unit entitled 'evolutionary genetics'. I reviewed the syllabus document and came up with ideas I assumed would constitute 'evolutionary genetics'. I presented the following list to critical friends, colleagues and a science education expert for face validation: *speciation, inheritance, alleles, variation in organisms, DNA, genes, chromosomes, sources of variations (mutations, independent assortment and segregation), mechanisms of evolution, evidence for evolution and human evolution*. This initiated cycles of reflection and rethinking.

CF 1: *Add protein synthesis, meiosis and mitosis. You know, protein synthesis, meiosis, and mitosis all involve genes in one way or another, so they are part of genetics.*

My responses:

Meiosis: I concur with her on the notion of 'cross over that occurs in interphase 1 of meiosis' and also on the idea of 'independent meiotic alignment during metaphase 1' as these are causes of variation in organisms of the same population.

Protein synthesis: Whilst I agreed with her that the type of proteins formed eventually determines the phenotype of the individual in terms of its physical looks, behavioural capabilities and physiological potential, I regarded that these were not core issues for understanding evolutionary genetics.

Mitosis: I decided to exclude mitosis because it only happens in somatic cells, which are not passed to offspring during fertilization. When I shared these responses with my critical friend for the second time, she raised no objections.

When a **biology expert** was asked to further validate the list, she suggested I add *'Alternatives to evolution'.*

My response was that I had deliberately left out 'Alternatives to evolution' because these erroneously portrayed that there are other theories of evolution that can be used to explain the diversity of life. However, I also came to realise that the reason why my students were rejecting evolution ideas was probably because I had sidelined what the Expert was saying. I thus came up with the phrase 'religion and evolution.' This phrase was then added to the list above. Before this study, I would blindly follow the structure of the syllabus without thinking about the implications to my students' understanding. However, continuous engagement with critical friends and experts about my challenges helped me to learn to approach my teaching critically and to realise that it is my responsibility as a teacher to solve and resolve pedagogical issues that I experience in my teaching. (***Theme 6: Curriculum content delivery is not just about following the way topics are sequenced in the syllabus documents, but it calls for rethinking and probing so that it becomes tailor made for maximising comprehension for each specific and unique group of students***)

What benefits or challenges (if any) are faced when using self-study for professional growth?

Benefits

This study established that because teachers learn best within their workspaces of work (e.g. Samaras, 2011), '**one has got to be in it and doing it'** in the light of feedback from others to

learn ways of addressing one's challenges of practice. Furthermore, unlike having external experts identify and research our dilemmas, and then recommend to us what to do, the **first-hand** experience associated with the self-study methodology brings in on the-job insights that are better told from a participant researcher's point of view. This is because, as asserted by Samaras (2011), engaging in a self-study inquiry enhances practitioner learning in their workspaces. In this inquiry, I learnt about teaching beyond my teacher training by drawing insights from feedback stemming from my critical friends' pool of expertise. This was mainly, as also noted elsewhere (e.g. Loughran, & Northfield, 1998), engaging in a self–study offers unlimited opportunities for one to learn from and with others. Furthermore, engaging in a self-study instils cycles of inert professional learning across the teaching of other topics after teaching one topic. After conducting this self-study, I seemingly developed a new teacher identity. The new identity is that now I readily open up about my pedagogical reasoning and actions. This has resulted in my getting valuable critical feedback from colleagues each time I face pedagogical challenges. This aligns with findings by Chetty and Lubben (2010), who find that teacher identity is informed and shaped by individuals one interacts with during practice.
It also emerged that through conducting a self-study, the idea of opening up for feedback during teaching provides opportunities for quick development of topic-specific pedagogical content knowledge (Mavhunga & Rollnick, 2017). This is because during the years I engaged in this self-study, I acquired pedagogical skills to teach the topics of evolution and genetics for student conceptual change and understanding, which is what I struggled to develop in my over 19 years of teaching experience. Thus, by engaging in this self-study, it reduced the time I needed to develop my topic specific PCK for teaching evolutionary genetics. This corroborates findings by Mavhunga and Rollnick (2017) that specify focusing on how to teach a specific topic at a given time enhances pedagogical skills on how to teach that specific topic.

In addition to this, through the scaffold set-up associated with a self-study methodology, I experienced five pedagogical shifts in terms of my evolutionary genetics content representation for students' understanding. **Firstly,** I acquired the will to overcome my challenge arising from unknown fears to let go of entrenched traditional practices and embrace new classroom practices. **Secondly**, collaboration, critique and feedback sessions from others challenged my subjective perceptions and interpretations about teaching evolutionary genetics in ways that could have been difficult if I had attempted to resolve my dilemmas on my own. This is because interactions with others 'scaffolded my learning of how to teach evolutionary genetics beyond my fears and zonal of proximal development (Vygotsky, 1978). **Lastly,** my classroom practice improved as I experienced pedagogical shifts in five key aspects: curriculum design, creation of a positive learning environment for students, teaching through multiple preferred learning styles, content sequencing for easy student understanding, and teaching for conceptual change.

Challenges

Theme 7: Making public one's teaching challenges makes one vulnerable

The balancing metaphoric image shown in Figure 11 will be used to express and depict my experienced challenges and insights after using a self-study collaborative approach as a strategy for professional development. In this self-study I 'got my hands dirty' (Samaras, 2011) in two ways. **Firstly,** I was directly involved in trying out new strategies on how I could become a better teacher of evolutionary genetics. **Secondly**, I made my pedagogical actions and reasoning vulnerable to 'attack' by making them public when I opened up for negative or positive critique (see Figure 10 below). Whilst I found the positive comments from critical friends to be a welcome development because they confirmed what I already knew about teaching, the negative and unfriendly comments turned out to be a bit insensitive to my integrity. This unwelcome social setup posed threats on posing resistance to changes in my identity as an individual as also noted elsewhere (e.g. Gilbert & Yerrick, 2001).

Figure 10.

My lived experiences of using a self-study approach as a strategy for professional development (Source: Tshuma, 2021)

Furthermore, whilst the negative comments were generally 'unwelcome', it emerged that they contributed more towards my professional development as depicted in Figure 10. This is because I spent more time reflecting on the negative comments and how to address them as raised by my critical friends. The 'negative' and 'positive' critiques are thus powerful critical reflection points for enhancing professional development which could have been difficult for me to get if the self-study was done entirely as an individual venture. Thus, this use of engaging in this self-study facilitated my professional growth as I had a chance to negotiate my new

teacher identity through probed internal reflections in the company of other educators and students as noted by scholars such as Chetty and Lubben (2010).

Furthermore, as unveiled in this inquiry and based on my lived experiences, it emerged that most of the time, as practitioners, we tend to work in silos because we find it difficult to open up to others for critiquing our pedagogical reasoning and actions. In this inquiry, I had trouble opening up about my pedagogical actions and reasoning due to self-pride, and fear of being judged as a 'weakling' by critical friends even though probably I faced the same challenges in my practice as others. However, in the end, it emerged that by opening up for others to critique one's pedagogical reasoning and action, the benefits of doing so far outweigh the pride and fear of being judged.

Furthermore, the notion that one can see teaching flaws through reflections emerged be a difficult challenge for me. This is because I struggled to discern flaws in my teaching that I could work on to improve my practice. Thus, the notion of my objectively critiquing my thinking turned out as a dilemmatic challenge. Due to this, it emerged that through getting involved in a self-study, which involves **opening up for others to comments, the** self-study researcher experiences tensions between what I coined the researcher's *'**inner egoistic voice**'* and the *'**outer voice**'* (critiquing comments from critical friends). Therefore, one can argue that our professional development as practitioners lies in our prowess to reconcile the tension between our *inner voices* and the most often 'unkind' or 'negative' *outer voice*s.

CONCLUSION

This inquiry foregrounds that whilst opening up for feedback and making one's pedagogical reasoning and actions open to others, not only exposes one to ***'attack'*** by critical friends, but it also offers opportunities for professional development beyond one's work training experience and expertise. This is because the '**negative**' and positive critiques from others are powerful **critical reflection points** for enhancing professional development which could be difficult to acquire if self-studies are to be done entirely as individual ventures. The critique from others offers continuous cycles of reflections and probing planes from a socio-cultural perspective (Vygotsky, 1978) which enhances processes of professional learning from others. Thus, the idea of reflections, opening up for critique and feedback from others on one's practice is a professional development process as it enhances learning beyond one's personal biases and interpretations.

This inquiry further established that whilst as practitioners we experience a tension between our *'**inner egoistic voice**'* and the *'**outer voices**'*, our professional development as practitioners lies in our ability and will to reconcile the dynamic and flexible boundaries between these two often antagonistic voices objectively. The outer voice is crucial for paving pedagogical shifts (new professional growth) in terms of enacting multi-strategy teaching approaches that cater for diverse students' preferred learning styles, identify students' typology of held prior unscientific ideas, teaching for conceptual change, sequencing content as a single coherent unit

for enhanced student understanding and the realisation that we are life-long learners who may never know it all at any one given time. This is because for us to deviate from our entrenched traditional practices, which are noted to be usually difficult and resistant (e.g. Gilbert & Yerrick, 2001), we need as what emerged in this study, a second voice to help interrogate our practices beyond our fears and biases.

Furthermore, through engaging in this reflexive self-study, it was insightful to note that 'one ought to be actively involved and on the ground' for one to get insights about what works and does not work in a quest to address own identified work challenges, or what other scholars (e.g. Lave & Wenger, 1991) describe as situated learning. In addition to this, it also emerged that the self-study approach triggers cycles of life-long learning prowess that continue as professional growth drives the teaching of different topics and subjects in the curriculum. After engaging in this inquiry, my pedagogical approaches when teaching have drifted from my traditional approaches of talk, chalk and textbook. This is because I now feel uncomfortable when trying to use them. After all, I now understand their flawed teacher-centeredness rather than being student-centred (e.g. Lefstein & Snell, 2019).

From a pedagogical perspective, a number of professional growth enhancement factors emerged from engaging in this self-study. Firstly, identifying and using learner misconceptions to inform one's teaching is a professional development activity that changes one's approach to viewing misconceptions as being problematic, but opportunities to enhance student learning. Secondly, comparison of the misconceptions held by students in the context of those in the learning resources provide a unique opportunity that minimises the perpetuation and consolidation of held misconceptions. Thirdly, teaching in ways that uphold the students' diverse preferred learning styles does not only facilitate the majority of the student's conceptual changes but also brings about deep content understanding that enhance the discarding of held misconceptions, especially the acquired errors. Fourthly and finally, curriculum content delivery is not just about following the way topics are sequenced in the syllabus documents, but it calls for rethinking and probing so that it becomes tailor made for maximising comprehension for each specific and unique group of students. This bring in the spotlight the notion that as academics, the issue of curriculum design and redesign should be part of our life-long learning given any group of students.

Limitations and recommendations for future study: This study looked at the professional development of a single educator in a typical African context. Future studies may also involve other different educators in their different parts of the world and workspaces engaging in their self-studies of this nature. The findings from such different workspaces could then be compared to see differences and similarities as a possible avenue to develop a framework for using the self-study approach as a tool for professional development.

REFERENCE

Antonenko, P. D. (2014). The instrumental value of conceptual frameworks in educational technology research. Education Technology Research Development. 53-71. DOI 10.1007/s11423-014-9363-4.

Borko, H., Cone, R., Russo, N., & Shavelson, R. (1979). Teachers' decision making. In P.L. Peterson & C. M. Walberg (Eds). Research on teaching: Concepts, findings, and implications (pp. 136-160). Berkeley, C. A: McCutchan.

Clark, C. M. & Yinger, R. J. (1979). Teachers' thinking. In P.L. Peterson & C. M. Walberg (Eds). Research on teaching: Concepts, findings, and implications (pp. 231-263). Berkeley, C. A: McCutchan.

Chetty, R., & Lubben, F. (2010). The scholarship of research in teacher education in a higher education institution in transition: Issues of identity, 26(4), 813-820.

Cochran-Smith, M. & Lytle, S. L. (2004). Practitioner inquiry, knowledge, and university culture. In J.J. Loughran, M. L. Hamilton, V.K.

Comber, B. (2013). Teachers as researchers: A 'fair dinkum' learning legacy. English in Australia, 48(3), 54–61.

Creswell, J. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4thed.). Upper Saddle River, NJ: Pearson Education. Mixed Methods Research

Creswell, J. (2014). *Research design: Qualitative, quantitative, and mixed methods approach.* Thousand Oaks, CA: Sage Publishing.

Davis, R., Maher, C., & Noddings, N. (1990). Introduction: Constructivist views on teaching and learning of mathematics. Journal for Research in Mathematics Education, 4, 195-210. DOI: 10.2307/749908.

Flavell, J. (1979). "Metacognition and cognitive monitoring", American Psychologist, 34(10), 906-911.

Gilbert, A. & Yerrick, R. (2001). Same school, separate worlds: A sociocultural study of identity, resistance, and negotiation in a rural, lower track science classroom. Journal of Research in Science Teaching, 38, 574-598.

Glennie, S. & Cosier, J. (1994). Collaborative inquiry: developing multidisciplinary learning and action. Journal of Interprofessional Care, 8 (3), 255-263.

Glennie, S. & Cosier, J. (1994). Collaborative inquiry: developing multidisciplinary learning and action. Journal of Interprofessional Care, 8 (3), 255-263.

Gordon, J., Gabor, H., Magdalena, K., Michel, A., Pepper, D. Putkiewicz, E. & Wisniewski, J. (2011). Key competencies in Europe: Opening doors for life-long learners across the school curriculum and teacher education. Case – Centre for Social and Economic Research.

Hodson, D. (2014). Learning Science, learning about Science, Doing Science: Different goals demand different learning methods. International Journal of Science Education, 36(15), 2534-2553, DOI: 10.1080/09500693.2014.899722

Kaser, L, Halbert, J. (2014). Creating and sustaining inquiry spaces for teacher learning and system transformation. European Journal of Education, 49, 206–217.

Klingner, J. K. (2004). The Science of Professional Development. *Journal of learning disabilities,* 37 (3). https://doi.org/10.1177/00222194040370031001

Knowles, S. (1975). Self-Directed Learning: A Guide for Learners and Teachers. New York: Association Press.

Krippendorff, K. (2013). Content analysis: An introduction to its methodology. London: Sage Publishers.

Krolak-Schwerdt, S. & Glock, S. (2014). Teacher's Professional Development: Assessment, Training, and Learning. The Netherlands; Sense Publisher

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press

Lefstein, A. & Snell, J. (2019). *Better than best practice: A case study for improving teaching and learning*. Retrieved on the 13th of April 2019 from http://dialogicpedagogy.com/about-the-book

Loughran, J. J. & Northfield, J. (1998). A framework for the development of self-study practice. In M. L. Hamilton, S, Pinnegar, T, Russel, J. Loughran, & V.K. Laboskey (Eds). Reconceptualizing teaching practice: Self-study in teacher education (pp. 7-8). London: Palmer.

Mavhunga, E. & Rollnick, M. (2017). Implementing PCK Topic by Topic in Methodology Courses. ResearchGate. DOI - 10.1007/978-94-6300-881-5_9

Mavhunga, E., & Rollnick, M. (2017). Implementing PCK topic by topic in methodology courses. In *Designing and teaching the secondary science methods course* (pp. 149-170). Brill.

Mead, R., Hejmadi, M., & Hurst, L. D. (2017). Teaching genetics prior to teaching evolution improves evolution understanding but not acceptance. PLoS Biol., 5 (5), 1-30. doi.org/10.1371/journal.pbio.200225.

Miles, M. B. & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook (2nd Ed.). Thousand Oaks, CA: Sage. Ministry of Education (2010). Teaching syllabus for Clothing and Textiles. Accra: Curriculum Research and Development

Owusu-Mensah, J. (2016). Improving the Pedagogical Content Knowledge (PCK) of Mathematics Teachers to Enhance Student Learning and Understanding. *Journal of Mathematics*, 12(5), 66-70. DOI: 10.9790/5728.

Patton, M. (1996). Utilization-focused evaluation. Thousand Oaks, CA: Sage Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage.

Pinnegar, S. & Hamilton, M. L. (2011). Self-study inquiry practices: Introduction to self-study inquiry practices and scholarly activities. In S. Schonmann (Ed.), Key concepts in theatre/drama education (pp. 345-352). Rotterdam: The Netherlands: Sense.

Pinnegar, S. (1998). Introduction: Methodological perspectives. In M. L. Hamilton, S. Pinnegar,

Sagor, R. (2000). Guiding School Improvement with Action Research. New York: Association for Supervision and Curriculum Development.

Samaras, P. (2011). *Self-study teacher research: Improving your practice through collaborative inquiry.* Thousand Oaks, California: Sage.

Shuck, S. & Russell, T. (2006). Self-Study, Critical Friendship, and the Complexities of Teacher Education. A journal of self-study of teacher education practices, 1 (2), 107-121.p

Shulman, A*., &* Calabi, P. *(*2012*). Cognitive constraints on the understanding and acceptance of evolution. In* K. S. Rosengren*,* E. M. Evans*,* S. Brem*, &* G. M. Sinatra *(Eds.),* Evolution challenges: Integrating research and practice in teaching and learning about evolution *(pp.* 47–65*).* New York*: Oxford University Press.*

Shulman, L. S. (1987). Knowledge growth in teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1-22.

Shulman, L.S. (1986). Those who understand knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

Teddlie, C., & Tashakkori, A. (2009). Foundations of mixed methods research: Integrating quantitative and qualitative techniques in the social and behavioural sciences. Thousand Oaks, CA: Sag

Tshuma T. (2021). The teaching of evolution to Grade 12 students: A dilemma driven self-study inquiry. PhD research report. University of the Witwatersrand, Johannesburg.

Tshuma, T. (2020). Bringing back the delight of teaching science ideas: A case of evolutionary genetics. Proceedings of the Twenty-Ninth Annual Conference of the *Southern African Association for Research in Mathematics, Science, and Technology Education*. 13-17 January 2020. Nelson Mandela and Rhodes University. Grahamstown. pp. 369-387.

Tshuma, T. 2023. The Impact of Covid-19 on Academic Practice: A Dilemma-Driven Self-Study Inquiry at an Institution of Higher Learning. Research in Social Sciences and Technology, 8(3), 67-88. https://doi.org/10.46303/ressat.2023.21.

Vygotsky, L.S. (1978). *Mind and Society: The development of higher psychological processes*. Cambridge, M.A: Harvard University Press.

Yates, B. & Marek, A. (2014). Teachers teaching misconceptions: a study of factors contributing to high school biology students' acquisition of biological evolution-related misconceptions. *Evolution: Education and Outreach*, 7 (7), 1-14. Doi: 10.1186/s12052-014-0007-2.

Yin R. K. (2011). Qualitative research from start to\ finish. New York, NY: Guilford Press.