To investigate the effectiveness of Japanese Lesson Study as a collaborative professional development activity for teachers at school level.

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Exploring the effectiveness of the Japanese Lesson Study as a collaborative professional development activity, aimed at improving the content knowledge and instructional strategies for a group of Life Sciences teachers, specifically in relation to Meiosis.

By

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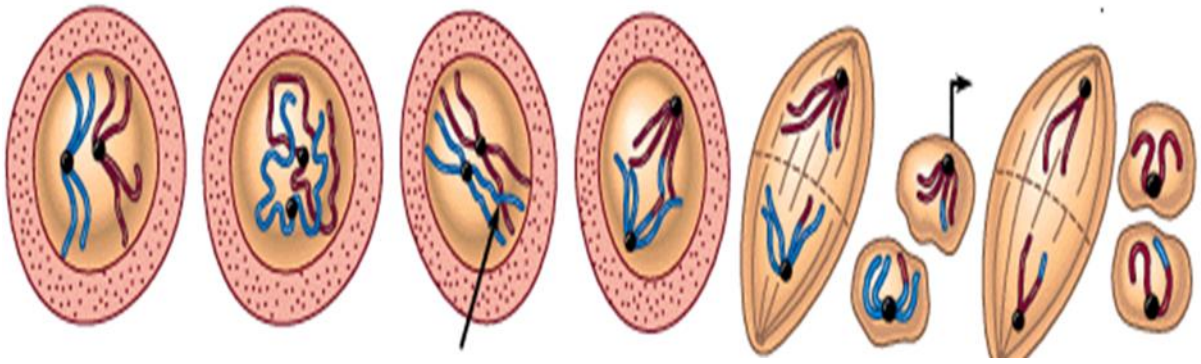
A research report submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial completion for a Degree of MSc in Science Education.



Abstract

The South African schooling system has experienced the development of four different curricula since 1994, which necessitated continuous Professional Development activities for teachers. However, despite these Professional Development programmes, teachers continue to experience problems with their teaching. Possible reasons are that Professional Development activities do not focus on the needs of individual teachers. This motivated for an exploratory type of research in which five Life Sciences (LSs) teachers and a content expert from a local university participated. The researcher of this study organised and facilitated Professional Development activities that involved meiosis at school level. Four teachers from different schools were involved using the Japanese Lesson Study approach (JLS). The data tools involved were propositional knowledge statements that described topic specific content and videotaping the lesson study. The findings of the study showed that the Japanese Lesson Study approach afforded all the participants the opportunity to identify and rectify their individual errors. In addition, the reviewing of the meiosis lessons from the videotapes afforded the participants an opportunity to evaluate their respective instructional strategies applicable in relation to the transformation using the five components of the Topic Specific Pedagogical Content knowledge theoretical framework for this study. The overall results depicted that the meiosis content knowledge in relation to its teaching improved satisfactorily when using the Japanese Lesson Study approach. The implications of this study in the education field is that professional development activities need to redress the content knowledge gaps identified by the teachers themselves including the attainment of effective teaching strategies with the help of the content expert, which will promote learners' understanding.

Declaration

I declare that this research report is my own unaided work. It is being submitted for the Master's Degree in Science Education at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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(Signature of the candidate)

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Chapter 1

Background to the study

Professional Development (PD) describes the opportunities that are made available for educators to help them develop or to improve their professional knowledge, competences, skills and effectiveness (Bruce & Calhoun, 2010).

In South Africa, there is evidence of Professional Development (PD) activities prior and post-apartheid regime that accompanied the different curriculum reforms which included workshops, seminars, cluster meetings, road shows, courses and conferences. (Mokhele, 2014). However, despite these Professional Development (PD) programmes, teachers continue to experience problems with their teaching because the Professional Development (PD) activities do not focus at the needs of individual teachers. This is the motivation for this study. The study investigates the effectiveness of the Japanese Lesson Study (JLS) as a collaborative professional development activity. It is aimed at improving the content knowledge and instructional strategies for Life Science teachers in relation to Meiosis. Ono & Ferreira (2010) describe the Lesson study as a type of classroom research that involves teachers investigating their own teaching and students learning in the context of a single class lesson. The undertaking of the Lesson Study is assisting teachers to develop their teaching skills for continued and sustainable professional development. (Doig & Groves, 2011; Ono & Ferreira, 2010). The elaboration on the Japanese Lesson Study and its application happens in chapter two of this study.

1.1. Context of the study.

Professional development (PD) introduces different forms of teaching enabling teachers to become reflective practitioners and empowered professionals. (Leu, 2004). In the South African context, the professional development is of critical importance because we are readdressing the inadequate training of teachers that has become evident in our students' poor performance in the Science and Mathematics subjects in comparison to the rest of the world (Kriek & Grayson, 2009). In South Africa the professional development activities applicable prior to 1994 were based on "a cascade model" (Leu, 2004). The cascade model advocates teachers to follow rigid patterns such as rote learning and little inclusion of teachers' content knowledge within the classroom. For example, the workshops involved the attendance of representative teachers in a district that teach a specific subject. This implied that each school needed to send a representative to attend a centralized workshop. The rest of the teachers needed to rely at the teacher that attended the workshop to pass on the new information. The workshops happened sporadically and the presentations involved an expert presenting the lecture that did not provide an inclusive learning program for the teachers attending. (Leu, 2004). Therefore, this study applied a professional

development activity that involved Life Sciences teachers at school level. Teachers met regularly to plan a science lesson and to discuss their content problems in relation to the meiosis topic.

In South Africa, meiosis is a grade twelve topic examined in both Paper 1 of the Matric (exit) examination and in terms of gametogenesis in human reproduction. It is also examined in Paper 2 genetics and cell division. Some of the content knowledge include the lack of conceptualization of scientific concepts that involve chromatid, chromosomes and gene (Dikmenli, 2010). In addition, the other content knowledge challenges involve the relationship between cell division genetics and inheritance. (Lewis, Leach & Wood-Robinson, 2000). Another example advocating the need for this study involves teachers using both correct and erroneous models of chromosomes, genes behaviour during meiosis cell division (Steward, Hafner & Dale, 1990).

1.2. Problem statement

The South African schooling system introduced four different curriculums since 1994. The initial curriculum was Out-comes Based Education Curriculum. (C2005) (Department of Education, 1997); the National Curriculum Statement (NCS) replaced C2005, and was then revised to form Revised National Curriculum Statement the (RNCS) including Grades 1-10 (Department of Education, 2002); and it led to the conception of the National Curriculum Statement (NCS) for Grades 10-12 (Department of Education, 2003b). Currently the new curriculum practiced at the schools is the Curriculum Assessment Policy Statements. The Curriculum Assessment Policy Statements (CAPS) adheres to the principle of Human rights, inclusivity, environmental and social justice. It instils the principles and practices of social and environmental justice and human rights as defined in the Constitution of the Republic of South Africa. The National Curriculum Statement Grades R-12 is sensitive to issues of diversity such as poverty, inequality, race, gender, language, age, disability and other factors (Department of Basic Education, 2011).

The National Curriculum Statement Grades R-12 (January 2012) represents a policy statement for learning and teaching in South African schools and comprises of the following;

- Curriculum and Assessment Policy Statements for each approved school subject.
- The policy document, National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12
- The policy document, National Protocol for Assessment Grades R-12 (DOE, 2011).

Teacher professional development programmes accompanied the curriculum reforms in the form of workshops, seminars, conferences, cluster meetings, road shows, courses and conferences (Mokhele, 2014). However, teachers continue to experience problems with the Science content knowledge because the professional development activities do not focus on

the needs of individual teachers and the lack of content knowledge (National Policy Framework for Teacher Education and Development, 2006).

1.3. Significance of the study.

This study was school based and it focused on investigating the collaborative development of teachers' content knowledge and instructional strategies one topic at a time using the Japanese Lesson Study (JLS) approach. The questions that guided the study were:

How effective is the Japanese Lesson Study (JLS) as a collaborative professional development activity in regards to;

1.1 Content knowledge of a group of Life Sciences teachers?

1.2 Instructional strategies applicable in relation to meiosis?

2. What are the benefits and challenges, (if any) of using a Japanese lesson study activity as a professional development activity at school level?

1.4. Rationale.

The Curriculum Assessment Policy Statement (CAPS) advocates learner centeredness. The learners need to be active and critical thinkers and critical approach to learning, rather than rote and uncritical learning is of essence (DOE, 2011). These expectations bring into realization the central role of the teacher in the educational quality and the importance of continuous teacher professional development (Leu, 2004). However, there are debates amongst the researchers that the teacher Professional Development (PD) activities should not be in effective exercises that uses large sums of money without attaining the set objectives of ensuring that the teachers acquire extensive content knowledge and the support needed for its teaching. (Doig & Groves, 2011).

Lee (2011) state that the content experts who do not have the classroom experience when facilitating the professional development activities, are prone to ignoring the numerous teacher's classroom realities. Furthermore, the various student's prerequisites are not taken into perspective by the content experts during the training of the teachers. Research by Leu (2004) attests to my personal experience that teacher professional development activities need to be on going and they should allow teachers to be active participants in their own development. Active involvement implies that they collaborate in discussing critical content knowledge including instructional strategies with experts or critical friends. In addition, the teachers also engage interactively in these professional development activities by listening, observing, being observed and gaining feedback. This was the motivation for this study, to investigate the effectiveness of Japanese Lesson Study (JLS) as a model for small scale, sustainable professional development because it happens at school level with a group of science teachers in building a community of enquiry into their own teaching practices.

1.5. My position in this study.

I am a researcher participant in this study. Mitchell (2010) defines a researcher participant as a human subject who in the research is the target of observation by other researchers. According to Mitchell (2010), there is an advantage in being or having a researcher participant in a project. This is because the researcher's experience tends to have enormous benefit for the research community, encouraging participants' use of research to appraise their own practice.

In relation to my study, the reasons for being a researcher participant were as follows: Firstly, I wanted to gather extensive data from the other four participants on their meiosis content knowledge including my own, their respective instructional strategies applicable to its transformation and mine using Mavhunga (2012), Topic Specific Pedagogical Content Knowledge five components. Secondly, I wanted to ascertain the feasibility of the Japanese Lesson Study (JLS) approach as a professional development activity at school level concurrently applying Mavhunga (2012) TSPCK five components. Thirdly, the JLS approach is a professional development activity that is open to observation by the community, which might be overwhelming to the other participants. Therefore, to counteract this I had to immerse myself in the community of inquiry by the Life Sciences teachers in order to win their trust as a researcher. Gaining the other four participants' trust had to commence during the goal-setting phase of this study by the researcher participant stating that all of us were going to learn from each other in relation to our respective meiosis content knowledge, including various strategies applicable in its transformation to a point that learners understand it. Another strategy was to involve them in observing me teaching the initial meiosis lesson on video. I undertook this study after I had passed a module called "Subject matter knowledge'' which focused on the meiosis, genetics including inheritance content knowledge and its teaching. Subject matter knowledge focuses on the teacher having the same content knowledge as an expert and the ability to teach it effectively.

1.6. The organisation of the research report.

Chapter 1: This chapter enables the reader to understand the background to the study, its context, overall aim of the study, research questions and a brief explanation why the study was undertaken

Chapter 2: I selectively reviewed the relevant literature that elaborates on professional development including its various forms in the education. The other relevant literature reviewed spoke about the cascade model of professional development activities. Including literature review, that advocates a Lesson Study model as a sustainable professional development activity. In the discussions of the background for this study, I introduced

Mavhunga (2012) Topic Specific Pedagogical Content Knowledge (TSPCK) model as the theoretical framework that formed the basis for my study.

Chapter 3: This chapter focuses on the research methodology, application and instruments applied to collecting data, how the administration of the data happened including the issues of reliability, validity and ethics.

Chapter 4: This chapter presents the details of the method of analysis, clear description of my results supported by an in-depth discussion of the analysed data, tables, diagrams and extracts from the respective participants in this study including discussions.

Chapter 5: This chapter focuses on the summary of the results, answering the research questions, limitations, implications and reflections.

Chapter 2

2. 1. Literature review.

This section of the study focused on the literature reviewed from various researchers. Firstly, it discussed literature reviewed on what professional development is. As well as the purpose of the professional development activities and the challenges thereof. Secondly, this phase discussed the literature studied on the origins of the Japanese Lesson Study (JLS) as a professional development applicable in this study including its cyclic phases that the researcher intended to apply to gather extensive data for this study. Thirdly, literature on collaboration appraised for the study because a group of Life Sciences teachers who are participants formed a group at school level to deliberate on meiosis, design its lesson plan and teach it using the JLS cyclic phases. Hence, there is inclusion of discussions on the literature reviewed about the meiosis content knowledge to gather existing challenges including various teaching strategies already applicable to its execution within the classroom context. Fourthly, this section discussed literature reviewed to justify the use of Mavhunga (2012) Topic Specific Pedagogical Content Knowledge (TSPCK) model to gather data to answer the following:

1. How significant is the Japanese Lesson Study (JLS) as a collaborative study? and How effective is it in improving;

1.1 Content knowledge of a group of Life Sciences teachers

1.2 Instructional strategies applicable in relation to meiosis

2. What are the benefits and challenges, (if any) of using the JLS as a professional development activity at school level?

2.1. Professional development.

Caena (2011) explains that professional development activities aim to develop individual's skills, knowledge and expertise. Guskey (2000) attests to this explanation by adding that professional development activities improve teachers' attitudes as well. The understanding of the subject matter is an essential crucial component in professional development. This benefit will assist teachers' planning choices including the use of instructional strategies. The teachers will be proficient in answering whatever questions learners have during class (Gess-Newsome, 1999).

Shulman (1986) describes content knowledge as an important knowledge base for teachers. Content knowledge base relies on two fundamentals. They are accumulative literature and studies in the content area that includes the historical and philosophical scholarship

knowledge in that field. The science teachers content knowledge needs to be at the same level as that of scientists, they must understand the domains of empirical science, their rules and their application in the real world.

The teacher needs to comprehend alternative theories of interpretation and criticism and be able to link these issues to the school science curriculum and teaching (Shulman, 1987). Besides having profound content knowledge, teachers need to develop the relevant skills to teach the content effectively (Shulman, 1987). Research indicates that the content knowledge of South African teachers in the Science and Mathematics subjects is not extensive, which contributes to our students underperforming when compared to other countries world-wide (Rollnick & Brodie, 2011).

Rollnick & Mavhunga (2014) confirm that South African teachers in science lack content knowledge including skills of its delivery in the classroom. This serves as an indicator that professional development of the teachers should be a cornerstone to the improvement of the quality of education in the education system. In South Africa, the training of teachers occurs in the form of cascade models. Cascade models of professional development activities are characterized by the transmission of facts and the challenge thereof is the loss of a relevant content. The cascade models of professional developments are centred on a content expert who offers the workshops and presentations through presentations or lectures that rarely have a comprehensive learning programme. The roles of the teachers in cascade models type of professional development are mostly listening and asking clarity seeking questions (Leu, 2004).

The cascade model of development activity suits the planners in the education system because it is cost effective; the existing teaching staff work as co-trainers that have received pre -training from the experts and it brings about change on a large-scale. However, the disadvantage of using a cascade model training activity is that different trainers occupying the successive tiers of the cascade. This has the potential to dilute the training because vital information gets lost when transferred from one individual to another (Lave & Wenger, 1991). On the other hand, there are professional development activities that are collaborative and constructive because they enable teachers to be active participants and attain problem solving skills (Leu, 2004). An example of such a PD activity is the Japanese Lesson Study (JLS).

2.2. A Japanese Lesson Study.

The Lesson Study as a model of professional development originates from Japan and it continues to spread globally (Doig & Groves, 2011). The Lesson Study in Japan is not funded or compulsory; it unfolds at school level where teachers form their own communities of inquiry. The communities of inquiry collaboratively design their own lesson plan and experiment with classroom practices in depth (Doig & Groves, 2011). The Lesson Study is implemented in a cycle that involves planning together, teaching the lesson and lesson

observations, discussing the lesson and re-teaching the lesson on any particular aspects that needed improvement (Doig & Groves, 2011).

A review of studies by Ono & Ferreira (2010) indicate that the advantages of the Lesson Study is that it offers the teachers an opportunity to explore conflicting ideas when they discuss and maybe resolve conflicting goals in relation to education. Another advantage of the Lesson Study cycle is that it offers individual teachers an opportunity to assess their content knowledge and the effectiveness of their instructional skills for the first time because previously they were working as individuals with no platform for support and development.

The exploration of literature by Ono & Ferreira (2010) and Doig & Groves (2011) reveals that the Lesson Study is a continuous professional development model characterized by the teachers collaboratively designing a lesson plan and there is evidence of interaction between the group members through all the phases of the lesson study cycles. Collaboration in relation to the study implies that teachers learn and work together to achieve a certain goal. Furthermore, teachers create a collective capacity to commence and sustain continuous improvement in their professional practice to the benefit of the students who receive high quality instruction (Brownell, Adams, Sindelar & Waldron, 2006).

The Japanese Lesson Study has cyclic phases: such as; goal-setting, lesson planning, teaching and observing of the research lesson phase and post lesson discussions. The goal -setting forms the initial phase for the Japanese Lesson Study since it forms the introduction of the entire process of the study (Doig & Groves, 2011). The second phase is the lesson planning that involves the use of and exploration of a large number of instructional materials, curriculum documents, textbooks and reports from previous lesson studies intensively. During this phase, the teachers discuss students' misconceptions and the difficulties associated with the students not conceptualizing the content of the topic being taught. This includes the challenges the teachers themselves have. In addition, when teachers are involved with the lesson planning they are able to link the content knowledge of the specific science topic to other learning areas and to the science domain (Doig & Groves, 2011).

The third phase of the Japanese Lesson Study involves the teaching and observation of the research lesson while it is being videotaped. However, an observation by the peers while teaching has not been attempted within the South African context where lesson study has no evidence of practice. Teacher observation by peers while teaching in South Africa happens during a session of IQMS (Integrated Quality Management Systems) a quality assurance activity recognized by the Department of Basic Education (DOE, 2005). In addition, attesting to the aspect that it is illegal to have professional development activities within the contact time is evident in the GDE research protocol, which states that the research projects conducted at school level, need not disturb the teaching and learning time

(GDE research approval letter, 2016). The teaching and observation activity provides the opportunity for the teacher to transform the content knowledge in the classroom while being observed by peers leading to reflection. Live observation is central because the observers provide information about the classroom surrounding and the behaviour of both the teachers and the students in the study (Opie, 2014).

The fourth phase of a Japanese Lesson Study cycle involves the initial post-lesson discussion. The initial post-lesson discussion phase focusses on the teaching of the first research lesson that occurred in the real classroom and it is videotaped. The observed teacher and the observers take turns to give feedback, specifically on the transformation of the content knowledge in the classroom environment by looking at the areas that were good and those that needed improvement. The feedback from the participants leads to the design of the second lesson whose enactment involves other participants taking turns in teaching it (Doig & Groves, 2011).

The fifth phase of the Japanese Lesson Study encompasses one of the collaborators involved in the community of inquiry taking turns to teach the second lesson while being observed by peers and the entire lesson is videotaped. This is followed by the last phase of the Japanese Lesson Study, which is the second or final post lesson discussions chaired by the content expert. During this phase, both the observed teacher and the observers including the content expert give a final feedback on the teaching of the second lesson. The feedback leads to another modified lesson that all the group of teachers file for references or use for their respective teaching in future. In this study, the second post lesson discussions involved the feedback in relation to the teaching of the second videotaped lesson, which was followed by a reflection session on the Japanese Lesson Study approach itself whose deliberation at length occurred in chapter 3 of my study.

2.3. Collaboration.

A theorist Vygotsky (1978) states that learning happens within informal and formal social context through reading, writing, seeing, touching, smelling, tasting and language is central during the entire process and learning happens under the supervision of a well- informed individual. A well-informed individual scaffolds supports the learners through the entire process by identifying tasks that the learners can complete on their own and guiding the learners through the complex tasks up until they can be individually manipulated. In relation to this study, collaboration was evident in all the JLS approach phases. For example, the dialogue between all the participants was more evident during the workshops, which involved deliberations on the meiosis content knowledge. The evidence of writing was when all the participants answered the questionnaires including the propositional knowledge statements. The confirmation of seeing involved the observation of the videotaped meiosis lessons. Finally, the presence of the content expert guided all the participants through the meiosis content knowledge gaps.

My study required a group of Life Sciences to form a community of inquiry at school level. The community of inquiry is formed by a group of individuals involved in educational experience characterized by social presence, cognitive presence and teaching presence. Social presence allows the members of the specific group to engage, support each other in a desirable climate to reach the set goals. Cognitive presence allows the group members to apply the method of inquiry to reach the set goals using five essential features that include questions, evidence, explanations, linking prior knowledge to relevant scientific understanding and justifying knowledge claims. The teaching presence allows interaction, redirection of goals (Hassard & Dias, 2009). The community of inquiry of Life Sciences teachers in the study allowed them to deliberate, discuss and bring forth meiosis content knowledge problems including its teaching. The goal for the community of inquiry for my study was to improve meiosis content knowledge to a certain extent including its teaching. There was evidence shared responsibility and accountability during the data collection cyclic phase when the participants engaged on the content during the workshops and when they gave feedback on the teaching of meiosis lesson as depicted on the videotapes.

The base for successful collaboration was the synergism of motivation and interpersonal relationships because I knew whom I wanted to collaborate with because they were willing to participate as Life Sciences teachers. Furthermore, the participants came up with solutions to achieve the set goal of ensuring that this study happens because there was no competition. In addition, Collaboration involved planning together, which required the establishment of ground rules that showed respect; promoted cooperation to allow all the members to ask questions for clarity and to resolve problems. Collaboration in this study needed clarified accountability in relation to the portfolios in the community of inquiry and the set deadlines (Hassard & Dias, 2009). In relation to my study, the teachers involved in its community of inquiry were invited to be participants according to the Ethics and were made aware of their respective roles that are elaborated upon in chapter 3.

2.4. Meiosis content knowledge.

Literature reviewed in relation to meiosis content knowledge and its teaching by Smith & Kindfield (1999) state that teachers from the studies they have conducted indicate that student struggle with the scientific terms applicable in cell division and the microscopic nature of cell division. Teaching and learning of meiosis within the South African Life Sciences curriculum context requires the following; to include the revision of the structure of a cell including the cell cycle, knowledge of the structure of chromosomes, phases of meiosis I & II, importance of meiosis, non-disjunction including its consequences and the differences between mitosis and meiosis. However, the grade twelve-examination diagnostic reports from 2013 to 2016 emphasize the need for the teachers to teach meiosis with the context of the cell cycle to correct the students' misconceptions (DOE, 2016). For example, some of the students' misconceptions are that interphase is part of the phases of meiosis and the cell rests during meiosis. In addition, the students as depicted from the

grade twelve examination diagnostic reports struggle with the scientific terms that include homologous and homozygous.

Dikmenli (2010) indicates that student teachers themselves have difficulty in the understanding of chromatids, chromosome and homologous chromosomes. This aspect showed the need for this study because Yip (1998) state that teachers themselves can be the source of the misconceptions and erroneous scientific ideas when they do not have extensive science content knowledge. Therefore, the purpose of the study was to bring forth teachers' misconceptions and erroneous meiosis concepts. In addition, if there were any this study provided a relevant platform using a JLS approach to unearth and deliberate on them.

Marbach-Ad & Stavy (2000) state that microscopic cellular level poses a challenge for students to comprehend because it cannot be experienced through touching. In addition, the observations of chromosomes and their behaviour during meiosis I and II are possible through a microscope. Microscopes make visual observation extensively restrictive because they allow only the sense of sight and not all schools can afford them because they are expensive. Hence, this contributes to the student's challenge with the abstract nature of the behaviour of homologous chromosomes including the structure of chromosome as attested to in the findings of the grade twelve-examination diagnostic report (DOE, 2016). The grade twelve examination diagnostic report indicates that learners' drawings of the homologous and single chromosomes in meiosis do not show certain gene segments that have broken off from their sister chromatids during synapsis. This challenge is evident in the respective learner's explanation of the behaviour of homologous chromosomes, which extends to the related science topic of genetics (Dikmenli, 2010). The above learning challenges prompted me as a researcher to investigate if they existed and if any surfaced, would the JLS approach help to resolve them.

The grade twelve-examination diagnostic reports recommend the teaching of meiosis within the cell cycle context to eliminate students' misconception that meiosis is a rapid division of a cell. Smith & Kindfield (1999) attests to this recommendation and they indicate that teachers in those studies conducted, are aware that the overall understanding of cell division forms the foundation for the learning of genetics and evolution. This element of linking meiosis to reproduction, genetics and evolution is not evident in the South African Life Sciences curriculum framework. It is an aspect, which is left in the hands of the teachers and it is attainable through teachers being content knowledge experts. The linking of meiosis to genetics, reproduction and evolution needs to be evident in the South African Life Sciences curriculum and not left in the discretion of teachers. For example, the curriculum needs to encourage the teachers to make the students aware when teaching the prophase 1 of meiosis that crossing over and mutation lead to genetic diversity that is observed in the offspring. In addition, the curriculum needs to motivate the teachers to teach that metaphase 1& II involve the random attachment of homologous or single

chromosomes, which needs linkage with Mendel's Law of independent assortment that promotes genetic variation including mutation.

Another example involves the discussions of anaphase I & II that offer an opportunity to link with Mendel's law of segregation. Mutations may happen during the phases of meiosis that links with natural selection and evolution. In addition, meiosis forms gametes that link with human reproduction. Additional proof that the South African curriculum does not promote curriculum saliency is evident in the manner in which meiosis and the related topics are supposed to be taught. For example, meiosis teaching is followed by a related topic, which is human reproduction and genetics. However, evolution that is related to meiosis its teaching happens at the end because it is the last chapter. This serves, as indication that the teaching related chapters does not happen and it is only the teachers that have the content knowledge of an expert, who has the ability to link or indicate links of the related topics to the students. Hence, the need for this study because it investigates the extent of the JLS approach, as a collaborative professional development activity, effective in improving the meiosis content knowledge of a group of Life Sciences teachers. Especially since literature reviews by Rollnick & Mavhunga (2014) state that in South Africa most science teachers' have science content knowledge gaps including the inability to apply relevant skills for practice to a point that those learners understand it.

2.5. Instructional strategies.

Shuman (1987) state that it is not enough for a teacher to have the content knowledge of an expert, however, the teacher needs to have skills to transform the content knowledge to a point that the learners understand it. Hence, this study does not only investigate the extent of meiosis content knowledge that the participants have and to what extent it improves through the JLS approach. This study takes it further by looking at the instructional strategies applied by the respective participants in this study to transform the meiosis content knowledge according to the requirements of the CAPS document (DOE, 2011). The general aims in the Curriculum Assessment Policy Statement (CAPS) document has numerous statements that suggest teaching strategies that are learner centred:

- 'learners should be able to identify and solve problems and make decisions using critical and creative thinking' (DOE, 2011, p.5);

- 'Organise and manage themselves and their activities responsibly and effectively' (DOE, 2011, p.5);

- 'To provide the opportunity to develop the learners the ability to be methodical, to generalize, make conjectures and try to justify or prove them' (DOE, 2011, p. 8).

Literature reviewed for this study showed various strategies applied to transform the meiosis content knowledge to a point that learners understand it. Smith & Kindfield (1999) suggests that teachers need to use instructional activities that offer students multiple

modes of learning that is seeing, touching, reading and hearing. Examples of such activities include the use of manipulative, video microphotography, videos depicting the phases of meiosis, conventional diagrams (e.g. Dikmenli, 2010), role-playing and models (clay, pipe cleaners and pop beads) to show the structure of a chromosome and the phases of meiosis.

Dikmenli (2010) indicates that drawings applicable in meiosis allow misconceptions to emanate and some of them are that crossing over happens during metaphase 1 of meiosis, DNA replication occurs between anaphase and telophase of meiosis.

Therefore, these researchers suggest the use of clear, carefully planned and simplified diagrams to correct the students' erroneous diagrams and misconceptions emanating from them. Furthermore, Kindfield (1993/1994) recommends that the students need to learn to interpret and utilize conventional diagrams along with conventional linguistic forms so that a meaningful understanding of the phases of meiosis occurs.

Smith & Kindfield (1999) caution that models are a true representation of components of meiosis however, no model is perfect. The focus of my study is on the meiosis content knowledge and its teaching. Furthermore, I have taken into perspective that the transformation of the meiosis content knowledge does not only involve the instructional strategies but other components. Hence, Mavhunga (2012) TSPCK model was chosen as a theoretical framework for this study. Mavhunga (2012) TSPCK theoretical framework states that the transformation of the content knowledge to a point that learners understand it includes these components: students' prior knowledge, curriculum saliency, what makes topic easy or difficult to teach, representations including analogies and conceptual teaching strategies.

2.6. Theoretical framework.

The theoretical framework that was applied in this study was Mavhunga (2012) Topic Specific Pedagogical Content Knowledge (TSPCK) model. The basis of the TSPCK model in this study is situated cognition. Lave & Wenger (1996) defines situated learning a process that unfolds in a participatory context in communities of practice that involve people engaging for substantial periods in ongoing activities that are interdependent and learning is an integral part in the acquisition of new knowledge. TSPCK is a theoretical construct that has the capacity to transform a specific topic through the five content specific components. The five components include students' prior knowledge, curricular saliency, what is difficult to teach, representations including analogies and conceptual teaching strategies. The quality of TSPCK is influenced by the knowledge of the five components as well their interlinking amongst each other. TSPCK focuses on both the content knowledge and the five components that are required for the transformation of that topic specific content. Hence, TSPCK model by Mavhunga (2012) was a suitable theoretical framework for this study in

which I investigated the effectiveness of a Japanese Lesson Study in developing teachers' content knowledge and instructional strategies for teaching a specific science topic. The five components of the TSPCK are described in detail below.

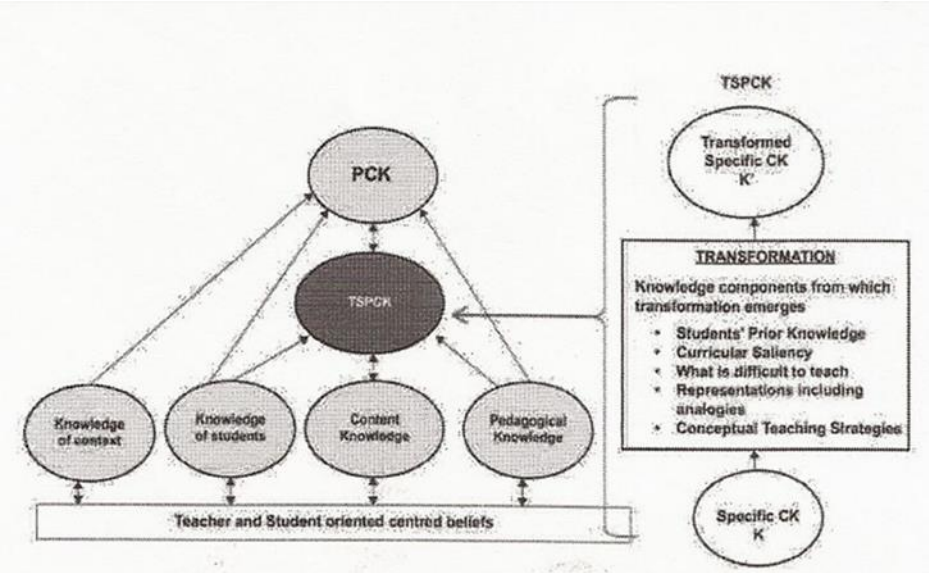

Fig.1. TSPCK model (Mavhunga, 2012).

The first component of Mavhunga (2012) TSPCK involved the students' prior knowledge. Students' prior knowledge encompasses everyday knowledge that the learners bring into the classroom environment. In addition, prior knowledge includes knowledge learnt by the students from their previous grades. Children use the abstract knowledge acquired through cultural experiences, media influences to make sense of their environment (Yip,1998). Usually, prior knowledge is informal knowledge that happens to be inconsistent with the relevant facts leading to the term 'misconceptions'. Yip, (1998) defines misconceptions as knowledge structures that individuals apply to understand certain situation that happen in a real world. Literature studied for my study showed different perspectives to the nature and sources of origin the of the learners' misconceptions in relation to meiosis. The students' misconceptions are not only the informal ideas structured through everyday experiences, which the students bring to class that may impede learning or lead to erroneous conception of relevant science. The other origins of misconceptions involve irrelevant views developed by the students during the classroom interactions and inaccurate concepts disseminated by respective teachers and textbooks.

Dikmenli (2010) stated that both students and teachers show errors in their respective diagrammatic representations of the phases of meiosis attesting to the literature by Yip (1998) that it teachers themselves who transmit incorrect scientific concepts to the learners because they have content knowledge gaps or erroneous conception of a specific science topics. A few examples of the misconceptions in relation to meiosis from the literature

reviewed for this study include firstly, that DNA replication occurs between prophase and metaphase. Secondly, chromosomes are formed due to the shrinkage and thickening of spindle fibres. Lastly, meiosis occurs in the reproductive (sperm or egg) cells and centrioles are found in the nucleus of the cell (Dikmenli, 2010).

The second component of Mavhunga (2012) TSPCK is curricular saliency. Curriculum saliency encompasses 'Big ideas'. 'Big ideas' involve how the specific science topic taught at school level link with the real science world practices, links with related science topic in a same grade, links to other science topic in higher grades and how it links with other subjects (Loughran, Berry & Mulhall, 2014). Furthermore, curriculum saliency involve sequencing of the 'Big ideas' in a topic according to the main and subsequent aspects for a teacher to be able to sequence chronologically what needs to be treated first in a topic and what needs to be left out (Loughran et al. 2014). For a teacher to be able to chronologically sequence concepts in a specific topic he or she needs to know the following. Firstly, the teacher needs to know what he or she intends the students to learn about this idea. Secondly, the reasons why it is important for students to know about this idea. Thirdly, what else the teacher might know about this idea he or she does not want the students to know yet. Fourthly, the teacher needs to know students' misconceptions in relation to a specific idea not only know them but also use mechanisms to enable the students to bring the misconceptions forth (Loughran et al. 2014). In addition, provide a socio-cultural environment that allows the students to deliberate on them to a point that they are willing to let go of them and embrace relevant scientific knowledge (Loughran et al. 2014). Fifthly, the teacher needs to know whilst planning the difficulties in relation to the teaching of the specific topic that may impede conceptual learning. Overall curriculum saliency requires the teacher to have knowledge about students thinking that influences his or her thinking about the topic at hand (Loughran et al. 2014).

The third component includes what is easy or difficult to teach and why is it difficult to teach that involved the ability to find the concepts considered difficult to learn, and identifying the actual issues that make their understanding difficult. For example, meiosis poses a challenge to teach because its teaching excludes other senses that involve touching and smelling. Its teaching is restricted to observation using microscopes, power point slides, models, drawings and videos. These teaching tools depict existing structures of chromosomes and their behaviour that the learners have to redraw and re model. Reviewed literature showed that most of learner's drawings of the behaviour of chromosomes during meiosis are incorrect, especially if they are copied from the textbook that has invisible micrographs. In addition, when models are applied to teach the behaviour of chromosomes during meiosis, the learners advocate them as the truth instead of representations of the relevant meiosis concepts (Dikmenli, 2010).

The fourth component is knowledge of representations including analogies. Representations are both mental activities and visual models encompassed in the teaching strategies to help learners understand the abstract concepts of a topic. Examples of representations applicable in meiosis include role-playing, use of play dough and drawings to show the behaviour of chromosomes during meiosis (Dikmenli, 2010). Chinnici, Neth & Sherman (2006) suggest the using chromosomal socks to demonstrate ploidy in meiosis including a simple string and paper game to represent the different stages of meiosis. However, literature showed that there are vast different representations to choose from to demonstrate phases of meiosis.

Therefore, this needs teachers to identify relevant representations applicable in the teaching of a meiosis topic. When identifying an appropriate representation to teach a specific topic the choice should be informed by the above-mentioned components and the fact that ultimately the representations need to lead to the conceptualisation of the relevant scientific concepts (Dikmenli, 2010). Analogies promote conceptual change by helping learners to get rid of existing misconceptions. However, Orgill & Bodner (2004) caution that students may grasp and literally use the analogy instead of the facts that it is intended to transfer. This study wanted to ascertain the evidence of the use of analogies during the teaching phase of the JLS and if applicable, did they clear off the students' meiosis misconceptions enabling them to understand the real scientific concepts. If analogies were not used during the teaching of the two research lessons during the data collection phase, their discussions will be omitted in the results and findings of this thesis report.

The fifth component encompassed in Mavhunga (2012) TSPCK are the conceptual teaching strategies. Literature lists different instructional strategies applicable in the transformation of meiosis content knowledge to a point that learners comprehend it (Smith & Kindfield, 1999). However, Mavhunga (2012) TSPCK a theoretical framework for this study advocates for conceptual teaching strategies. Conceptual change is a term demonstrative of learning science from the constructivist point of view (Duit, 2003). This implies that the teacher needs to think, implement instructional strategies that allows students prior knowledge to surface and not only emanate but that will challenge the students respectively to be dissatisfied with their initial idea and embrace the new idea, which is scientific relevant (Duit, 2003). In addition, (Duit, 2003) state that for a student to be dissatisfied with the initial idea and embrace the new relevant science concept it is because the new scientific relevant knowledge is intelligible, plausible and fruitful.

The intelligible conception means the student understands it because it makes sense to him or her. The plausible means that the student finds the new knowledge believable. Fruitful means the new knowledge enables the learners to resolve other problems (Duit, 2003). For example, this study applied instructional strategies that involved students' in their respective groups using modelling clay to depict the phases of meiosis. The thinking behind

this strategy was that student' misconceptions including erroneous ideas about the phases of meiosis may emanate. In addition, the students themselves may deliberate amongst themselves negotiating learning to an extent that those students that had incorrect perception of the phases of meiosis may correct them. The purpose for the use of these instructional strategies was to ascertain whether they prompted learners' understanding of the behaviour of chromosomes during meiosis and relevant scientific concepts that are difficult to conceptualize during the teaching of the two research lessons as suggested by Duit (2003).

2.7. Concluding remarks.

In this chapter literature by Bruce & Calhoun (2010), Caena (2011), Guskey (2000) and Leu (2004) was reviewed to acquire the educationists' definition of Professional Development (PD), which they describe as opportunities for learning that are made available to educators to help them to develop or to improve their professional knowledge, competences, skills and effectiveness. Continued review of the literature by Kriek & Grayson (2009), Gess-Newsome (1999), Mokhele (2014), Rollnick & Mavhunga (2014), Rollnick & Brodie (2011) and Shulman (1986), occurred to gather the different researchers' perspective in relation to the need of Professional Development activities globally and in South Africa and their variety of form.

Appraisal of the literature by Doig & Groves (2011) and Ono & Ferreira (2010) resulted in the explanation of Japanese Lesson Study approach and its advantages for the teachers. Literature by Dikmenli (2010), CAPS (2011) and Yip (1998) provided relevant information about the meiosis content knowledge and instructional strategies applicable in relation to its teaching. All the literature reviewed for this study led to the need to come up with research design and methodology to enable the investigation of the research questions. Elaborate discussions involving research design and methodology happens in the next chapter.

Chapter 3:

Research design, paradigm and methodology.

Introduction.

This chapter focused on the research design, paradigms and methodology for this study. Paradigms are systems of interrelated ontological, epistemological and methodological assumptions (Hatch, 2002), which acted as standpoints that provided a rationale for this research and guided the researcher participant to specific methods of data collection, observation and collection. In addition, discussions in this section involved the sample and instruments applied to collect the data including how the administration of the data unfolded and the issues of reliability, validity and ethics.

3.1. Purpose.

This study happened because of the need to investigate the effectiveness of the Japanese Lesson Study as a collaborative professional development approach aimed at improving the content knowledge of a group of Life Sciences teachers and instructional strategies in relation to meiosis.

3.2 Research paradigm and approach.

Paradigms are all encompassing systems of interrelated practice and thinking that define for researchers the nature of their enquiry along three dimensions. The first dimension is the ontology that specifies the nature and the reality to be studied. The second dimension is the epistemology that specifies the nature of the relationship between the researcher (knower) and what can be known. The third dimension specifies how the researcher may go about practically studying whatever he or she believes can be known (Hatch, 2002).

I applied an interpretivist paradigm, which states that multiple realities occur that are naturally unique because individuals who obtain the understanding of the world from their respective perspective create them. The epistemology dimension of the interpretivist paradigm, which was evident in the study, was one of the researcher participant and other participants co-constructing an understanding of meiosis content knowledge including its transformation. The methodology dimension of the interpretivist paradigm applicable was the qualitative research approach.

The study had qualitative research approach characteristics. Firstly, it applied an exploratory scientific method because the researcher participant investigated the theory with data that was collected from a group of teachers involved in the study. Secondly, the qualitative approaches examine the human behaviour as it unfolds naturally, holistically in natural setting. In relation to my study, all the participants interacted and deliberated on content knowledge in relation to the topic meiosis and its transformation applying the five components of TSPCK framework.

Thirdly, in a qualitative research approach the researcher uses data collecting sources that involve in-depth interviews and participant observation. In this study, the researcher participant and the other participants co-constructed the understanding of meiosis content knowledge including its practice using the JLS approach. Fourthly, qualitative research approach uses descriptive data analysis that searches for patterns, themes and holistic features (Cohen, Manion & Morrison, 2011).

3.3. Research methodology.

The research methodology for my research was a qualitative small -scale, case study whose findings cannot be generalized unless other readers or researchers see their application (Cohen, Manion & Morrison, 2011). Firstly, it was a small-scale case study because it was looking at PD of one group of teachers from a secondary school based in Gauteng. Secondly, it was a case study because the focus was on the real people who are the grade twelve Life Sciences teachers that are involved with the real situation of engaging with meiosis content knowledge and transforming it in a real life situation. Lastly, this study was a case study because as a researcher I am familiar with the environment in which the study unfolded in order to provide a detailed account of this study.

3.4 Limitations of the research methodology.

Stake (2013) indicates that although case studies have depth, they fall short of extensiveness. The study was limited in relation to size and it execution period. For example, the sample involved five Life Sciences teachers that were a component of a community of inquiry including and only six months was allocated for its data collection processes and writing of a research report for the Master's degree qualification. Therefore, the findings of

this study do not comprise all the Life Sciences teachers located within the jurisdiction of the research school or even to the entire Life Sciences teachers in Gauteng province. However, the findings of this case study can offer extensive information to both the Life Sciences teachers and the Education Department because presently in South Africa, there are no professional development activities that are school-based and specifically designed to redress contextual issues of the individual schools and teachers. Professional development activities evident in different learning areas cluster meetings include passing of the same level information from the facilitators to the teachers even though schools have different learning and contextual issues (Educator Development Schedule, 2016).

3.5. Participants.

The researcher was a researcher participant in the study. A researcher participant explores whilst observing and is observed by the other participants. The choice to be a researcher participant emanated due to the following reasons. Firstly, the JLS approach is not practised in South Africa and the researcher participant wanted to investigate to what extent will it improve her/ his content knowledge and its practice since it involves Life Sciences teachers working together at school level. Secondly, the researcher participant realised that the current professional development activities do not address content knowledge gaps including the teaching as it happens in the real classroom situation.

Therefore, the purpose was to ascertain what would happen if a few Life Sciences teachers can come together form a community of inquiry with the help of a content expert from the tertiary institution where the researcher participant is currently studying, which applies the JLS approach. The other participants were four life sciences teachers, a content expert and two grade 12 life sciences classes. The purpose of a researcher participant was to be close to the participants to gain their trust so and can have a first-hand experience on the understanding of their viewpoints and intentions in relation to the content knowledge of meiosis and its transformation through the five components of TSPCK discussed in depth in the theoretical framework. Also, gather the holistic view of the study by looking at other four participants including her/his own meiosis content knowledge and its transformation in a real classroom situation and ascertain the feasibility of establishing a Life Sciences community of inquiry at school level, which will continue to exist even after the completion of this study.

This platform of goal setting planning phase of the JLS approach allowed reassurance of the participants that all of us were collaboratively learning from each other including myself a researcher participant who facilitated the discussions of the propositional knowledge statements in workshops, post lessons discussions and reflections throughout the study. In addition, trust was edified with the introduction including the presence of the content expert who was there to clarify content difficulties and knowledge gap. **Table 1. Teachers profile.**

Table 1. Teachers profile.

Participants	**Age**	**Highest qualification.**	**Experience in teaching of Life Sciences**	**Role at school**	**Role in this study**
Researcher participant	51yrs.	Bachelor of Science. In Science Education (BSc).	22 yrs.	Head Of the Department of Life Sciences.	Facilitator, organizer, observed teacher researcher participant.
Liza	53yrs.	Secondary Teachers Diploma (STD).	20 yrs.	Teacher, Life Science and Natural Sciences	Participant, observer collaborator.

Betty	54yrs.	Secondary Teachers Diploma (STD) Higher Education Diploma (HED). & Further Education Diploma (FED), BSC (Science Ed) & Masters in Science Education (MSc).	28 yrs.	Teaching Life Science, Physical Science and Natural Sciences. & Maths, Science & Technology. Coordinator (MST).	Participant, observer collaborator.
Bony	27yrs.	Bachelor of Education (B.Ed).	4yrs.	Teacher, Life Sciences.	Participant, collaborator and observed teacher.
Tommy.	49yrs.	STD & HED.	21yrs.	Teacher, Life Sciences	Participant & collaborator.

The Participants mentioned in the table were invited because they teach Life Sciences at the research school. Betty was one of the master teachers at the time of this research facilitating Maths, Science and Technology programmes organized by the Gauteng Department of Education. The workshops were attended on some Saturdays and were in the subjects of Science and Technology. The master teachers attended training by specific tertiary institutions then facilitated the clusters.

In the original JLS, approach the content expert presents during the reflection sessions, which are the post lessons discussions that he or she chairs and offers feedback. (Ono & Ferreira, 2010). However, in this study the content expert was present throughout the study. In the planning phase, her role was to clarify, provide additional information and to rectify errors in relation to the content knowledge of meiosis during the extensive discussions of the propositional knowledge statements. The in depth discussions of the propositional knowledge statements occurred to ensure that content knowledge gaps and

difficulties were immediately rectified to counteract their transfer to learners during teaching. In addition, her presence was a strategy to promote confidence in the participants who were engaging in a JLS approach for the first time because in this study we needed one of the participants to volunteer for the enactment of the second research lesson. The last group of participants in this study were two classes of grade 12 learners, boys and girls, ages ranging between 17 to 18 years of age. The first research lesson was taught to one class of thirty-eight learners and the second research lesson was taught to the other class of forty-five learners.

3.6. Data sources.

The data collection tools for this study included propositional knowledge statements, interviews and videotaping of all the cycles of the lesson study, which are the goal setting phase, planning phase, enactment of the initial lesson plan, initial post-lesson discussions, enactment of the second research lesson.

3.6.1. Propositional knowledge statements (PKS).

Propositional knowledge statements describe topic specific content knowledge. (see Appendix B). Propositional knowledge statements are a new way of collecting data. For example, it involves identification of concepts individually followed by descriptive statements of what each concept mean. The descriptive statements referred to here as propositional knowledge statements were constructed by individual participants according to their own understanding of the identified concepts.

3.6.2. Workshops and videotaping.

Every phase of the lesson study was a source of data. The phases were done in the form of workshops involving the researcher participant who facilitated the workshops. The nature of each workshop was as follows: Initial workshop on the 7 July 2016 involved collection of propositional knowledge statements, which was followed by the discussion of meiosis concepts one by one, allowing each participant to give his or her explanation of the identified meiosis concepts. There was extensive use of literature in the form of textbooks. Disagreements were cleared through in depth explanations by the content expert. The second and third workshops commenced with the collaborative revision of the relevant meiosis concepts. In addition, each workshop ended with the re-visiting of the lesson study programme to accommodate any changes where needed. This was done to ensure attendance of all the participants and to act as a reminder about the next phase of the study. For example, at the end of the first workshop all the participants agreed to meet for the second workshop on the 14 July 2016.

All phases of the lesson study were video-recorded. The advantage of videotaping is that it preserved the natural setting of the JLS approach. All the participants' contributions were recorded including the content expert's contributions and the data was to be analysed at a

later stage. However, videotaping has its disadvantages, one of them being the accumulation of too much data which made some of it irrelevant and the transcribing was time consuming and the presence of the video recorder could have been intimidating (Opie, 2011). The videotaping applied in this study was ideal to provide the researcher participant and the content expert with resourceful data on whether a lesson study was effective in the improvement of the teachers' meiosis content knowledge including its practice as depicted in the two different grade twelve classrooms. Furthermore, videotaping in this study enabled checking of bias understanding of non-verbal endeavours (Opie, 2011).

3.6.3. Questionnaires.

Opie (2011) state that questionnaires as a data source tool in a research is effective, because it helps a researcher obtain written answers in relation to specific issues. In this study, I wanted in depth individual answers from all the participants' in relation to the effectiveness of the JLS approach itself. Especially since, all respectively completed the questionnaire on the day (5/11/2016) of the final post lesson discussions after the feedback sessions. In relation to the teaching of the second meiosis from the respective observation of its videotapes. The purpose for the administration of the questionnaire was to find answers to questions that involved what, why, where, how that participants were inclined to skip deliberately when interviewed because they require intensive thinking. Therefore, participants tend to repeat by seconding or agreeing with the former speakers when involved in a group interview, as it was applicable in the study.

When designing the questionnaire (see Appendix B) I considered the suggestions by Opie (2011) applicable in relation to the study. For example, the layout for my questionnaire was inviting to encourage the respondents to want read and answer it because there were clear boxes to tick their responses and fixed lines for their respective elaborations. The questionnaire had both open and closed questions.

The closed questions requested the respondents to individually choose an alternative answer by indicating YES/NO and explain their choice. Use of both closed ended and open-ended questions in my study catered for the participants' development, which stems from literature review by Opie (2011) stating that closed questions are simple to answer and quantify. However, their lack of choice hinders the respondents' chances to elaborate on aspects. In addition, the closed questions evident in the questionnaire enabled participants to elaborate freely without preconceived replies on individual questions (Opie, 2011).

CoRe (Content Representation) prompts are in the Mavhunga (2012). TSPCK that is a theoretical framework for this study became the questions in the questionnaire. Furthermore, the CoRe (Content Representation) prompts that are in the Mavhunga (2012) guided the phases of the JLS approach to create more structure for this study. By structure, I mean definite sequence on what is exactly supposed to happen in each phase namely: goal setting and planning phase, enactment of the two meiosis lessons and post lessons

discussions. The reason for applying this strategy was to counter act the problem depicted in the literature reviewed for this study by Ono & Ferreira (2010). The challenge encountered by Ono & Ferreira (2010) in one of their post-lesson forum in one district showed that South African teachers needed to learn what to observe during the Lesson Study and how to record their observations to avoid demoralising the teachers and to maximise the effectiveness of Lesson Study.

The use of the component of the CoRe (Mavhunga, 2012) was because they have been used in various researches (Loughran et al. 2014). Therefore, their use as questions attested to the validity and the reliability of this study. In addition, the researcher participant and the content expert took the fact that the participants had no knowledge of the components of the CoRe into consideration. Hence, during the goal- setting phase (7/7/2016) of this study the content expert explained the CoRe's and their use to all the participants. Furthermore, the researcher participant familiarized all the participants with the questionnaire on the day of initial post lesson discussions since it was going to be executed on the second/ final post lesson discussions as a mechanism of familiarizing the use of questionnaire for the second time because it was also done during the goal -setting phase. Therefore, piloting the questionnaire and ensuring its reliability and validity. The analysis of the respective questionnaires provided extensive data on the instructional practices, meiosis content knowledge and the benefits including the challenges of using JLS approach in this study. The content expert and the researcher participant explained the CoRe to the participants.

3.6.4. Interview

The group interview occurred using oral interview questionnaire (see Appendix B) on the 5/11/2016 during the second/ final post lesson discussions immediately after the individual completion of the written questionnaire by all the participants. The reason for having a group interview was that some participants might not answer the open-ended questions on the written questionnaire because they do not feel comfortable in articulating their views on paper but they are at ease with expressing them vocally (Opie, 2011). The interview was videotaped. It consisted of five questions that were open ended, which needed the respondents including the researcher participant to take turns to answer each question according to their respective thinking and understanding (Opie, 2011).

The interview was chaired by the content expert who allowed questions to seek clarity if they did not understand the question, probed gently all the participants to get in depth

answer from the participant, the tone of voice during the interview was polite and pleasant (Opie, 2011). The interview consisted of five questions encompassed in the components of the CoRe that all the participants were familiar with.

3.7. Data collection process

This study 's data collection process happened according to the data collection programme (see Appendix A) that depicted the phases of the Lesson Study cycle that are goal setting, planning, depiction of the different meiosis lesson plans, post discussion phases and reflection that happened concurrently with the final post-lesson discussion. The data collection process programme briefly outlined all the activities that occurred in relation to the identified lesson study phases, type of data source in each phase; commence dates and completion dates on which the phases of the lesson study cycle occurred and which data was sourced. The purpose of designing the data collection process programme involved ensuring that this study happened in a respectable, trustworthy manner, which ensured that all the participants are available and familiar with all the events and data sourcing tools (Opie, 2014).

3.7.1. The goal-setting phase, which was the step one of this study, occurred on the 7th July 2016 for four hours at the designated research school in Gauteng and it was videotaped. During this phase of data collection, all the participants including the researcher participant received instructions in relation to the completion of the propositional knowledge statements. For example, All the participants completed propositional knowledge statements in relation to meiosis individually before the first planning phase meeting and the second one was completed before the final post lesson discussion phase. The purpose of the individual completion of the propositional knowledge statements by all the participants was to acquire data in relation to the extent to which meiosis content knowledge of respective participants improved through the JLS approach.

The initial completion of the proposal statements by all the participants followed an in depth discussion in the planning phase. This discussion created a socio cultural platform for collaborative questioning, allowed individual participants to redress their misconceptions and restructure their content knowledge in relation to relevant science concepts (Hassard & Dias, 2009).

3.7.2. The planning phase was the second phase of the data collection process of this entire study that occurred for three continuous different sessions of in depth interactions on meiosis content including its practice from the 7 July 2016, 14th July 2016 and the 30th July 2016 that were videotaped. The undertakings during the 7/7/2016 workshop session involved collection of the initial propositional knowledge statements by the researcher participant for assessment. The analysis of the initial propositional knowledge statements provided an in depth data into the understanding of the instruction in relation to their completion. In addition, analysis of the initial propositional knowledge statements provided

data on the respective participants' meiosis content knowledge including its practice. For example, from the analysis of the initial propositional knowledge statements, which meiosis concepts and their explanations were correct, incorrect, meiosis relevant, and were for meiosis subsequent topics. All the workshops involved in depth deliberations on the meiosis content including its practice that were videotaped.

3.7.3. Teaching of the initial meiosis lesson

There were no observers in the teaching of the initial meiosis lesson and its lesson was not collaboratively designed. I taught the lesson for my subject matter knowledge course work project and my lesson plan (see Appendix B) was designed according to the CoRe components. The meiosis content knowledge, learning about the CoRe components and different ways of teaching to promote understanding by the learners were part of the subject matter knowledge. Therefore, the initial lesson design involved the CoRe components. In addition, all the participants were workshopped about the CoRe during the goal setting of the JLS approach to enable them to comment on my initial meiosis lesson according to the TSPCK components that are evident in the CoRe.

3.7.4. Initial post lesson discussions.

The initial post lesson discussions were videotaped and transpired on the 20th August 2016. They commenced with the observed teacher offering feedback on what areas were good and needed improvement in her teaching. Following this was the individual input from the participants in relation to which aspects were good and those that needed improvement in the practice of the initial meiosis lesson. A content expert gave her final input summarizing good areas and those that needed the improvement. The suggested inputs led to the collaborative design of the second meiosis lesson that included its teaching by another participant on the 23th August 2016. The transcripts of the enactment of the first meiosis lesson provided the researcher participant with an opportunity to look at her own meiosis content knowledge including its practice. In addition, transcripts showed that the rest participants observation of both meiosis lesson offered them an opportunity to look respectively into their own meiosis content knowledge and its teaching in their different classrooms. The transcripts depicting the feedback from the respective participants, which led to a design of the second meiosis lesson collaboratively of this lesson, cycle phase provided a valuable data on whether there was improvement in the content knowledge and instructional strategies when involved in the JLS approach.

3.7.5 Teaching of the second meiosis research.

One of the participants in the community of inquiry did teaching of the second meiosis lesson. The lesson plan executed in the initial meiosis lesson was modified according to the inputs of all the participants that had respectively observed the initial lesson.

3.7.6. Final/second post lesson discussions

This phase of the JLS approach occurred on the 5/11/2016, it was videotaped and it involved initially the observed teacher of the second meiosis lesson giving feedback on the aspects that were good and those that needed improvement in the practice. Secondly, all the participants gave feedback from their individual observation of the practice of the second meiosis lesson in relation to what were good and weak aspects. Thirdly, all the participants individually answered five questions from the provided questionnaire for twenty minutes (see Appendix B). Fourthly, the content expert asked five oral questions that allowed all the participants to alternate to answer them. Finally, the researcher participant collected the final propositional knowledge statements including the interview schedules from all the participants and thanked them for the sacrifice of their time to be participants in this study.

3.8. Data analysis.

This qualitative small-scale case study applied coding to interpret its data. Coding involved systematically searching data to identify and categorize specific observable actions. These observable actions then became the key variables in the study. The data analysis approach was both inductive and deductive. An inductive approach, which involves analysing data as it emanates from the research field and specifically for this research it involved the raw data including the summary of statements (Terre Blanche & Durrheim 1999).

Raw data analysis are transcripts presented to show how the participants responded during the videotaped workshops and the teaching of the two meiosis lessons. Those responses were categorized according to specific criteria. The summary statements data analysis approach are transcripts of participant's comments from the video tapes of the lesson study cyclic phases. This was done using themes, subheadings and quotations only where absolutely necessary to justify the points made.

The Content Analysis is a technique for analysing the content of text. The content can be words, phrases, sentences, paragraphs, pictures, symbols, or ideas. It can be done quantitatively as well as qualitatively (Terre Blanche & Durrheim 1999). The researcher participant analysed the meiosis content knowledge of all the participants in three ways. The first technique was assessing the meiosis concepts listed by the individual participants in their separate PKS 1 & 2 using different icons. Then the researcher participant designed categories according to the common icons arising across all the participants PKS 1 & 2. A deductive approach became evident when tables were used to show the results of the data analysis.

The second content analysis technique required the researcher to assess all the participants PKS 1 & 2. I read the meiosis statements form the participants PKS 1 & 2 to determine if they reflected correct understanding of the concepts. I then searched for patterns that emanated across all the participants statement in relation to the statements in the expected

list, which made the analysis deductive. The expected list that was designed by the researcher participant and approved by the content expert in this study (see the expected list of meiosis concepts in Appendix A). The common thread across the statements of all the participants became the categories that are the results. The third content analysis focused on looking at the occurrence of selected themes within the participants written questionnaires by examining trends and patterns in their different documents. In depth illustration of the results their discussions happened in chapter 4.

3.9. Reliability of the study

The research methodology for my research was a qualitative small-scale case study and literature showed numerous debates amongst the educationist in relation to validity and reliability in qualitative research (Opie, 2014). I was a researcher participant, actively involved in the lesson study to develop rich descriptions of the process. Therefore, the close involvement in this study could lead to the fact that this process of data sourcing, analysis and findings are subjective instead of being objective. Trustworthiness is the credibility, transferability, dependability and confirmability these concepts are adaptations of the qualitative researches statements to depict validity and reliability (Opie, 2014). To ensure that this study is not subjective I ensured that the entire study is videotaped, the participants wrote on their PKS and written questionnaires. It did not end there I encouraged that they verbalized what they had written on their respective PKS during the three workshops'. Furthermore, I ensured that they verbalize what they had written on their respective questionnaire during the group interview in the post lesson discussion of the JLS approach.

Therefore, as a researcher participant in this study a number of strategies unfolded to indicate the credibility of data sources tools, data analysis and its findings that they are worth paying attention to and worth taking account of (Opie, 2014). Firstly, this study was credible because the data gathering procedures were explained to all the participants during the goal-setting phase of the JLS approach, their authenticity approved upon by the content expert. In addition, the authenticity of CoRe components and its extensive use were evident in other reputable researches Cohen et al. (2011). All participants had data sourcing tools to preview, approve their understanding in relation to the study before use and individually used to source data. Secondly, all the participants were participated in workshops on how to use the data-sourcing tool that included the propositional knowledge, written questionnaire and components of the CoRe evident in the interview schedule. Thirdly, the transcripts of the videotaped actions of the different phases of JLS approach are dependable to provide credible information on the occurrences of the study, use of data sources, and data analysis to the community of inquiry and interested parties outside this study (Opie, 2014).

3.10. Validation

Validity is a demonstration that a specific instrument measures what it purports to measure, or validity is an account that correctly denotes all the required characteristics that needed to be described, explained or theorized. In qualitative research validity is measured through honesty, depth, richness and scope of data achieved from the transcript of feedback reports, workshops transcripts, and certain components of CoRe's applicable in Mavhunga (2012) TSPCK used in both written and interview questionnaires. In this study, validity was achieved using multiple data sources and the involvement of collaborators and the content expert throughout the data gathering process.

3.11. Ethics

Ethics is 'a matter of principled sensitivity to the rights of others', and that 'while truth is good; respect for human dignity is better' (Cavan, 1977).

University of Witwatersrand under which the study was undertaken. I (researcher participant) applied for permission from the University of the Witwatersrand ethics committee by submitting a detailed proposal. My study involved one secondary school in Gauteng where two respective classes of grade twelve learners needed to be taught meiosis whilst videotaped. Upfront invitation on video tapping of the learners during the teaching and observation phase of a lesson study cycle were extended school, teachers, Gauteng department of education, parents and the learners. The wording used in the invitations of the parents and learners was simple and understandable. An ideal endeavour because the Ethics considerations needed to be observed. Ethics has to do with the implementation of moral principles that the participants in the study are not in any danger, treated with respect, fairness, autonomy and good behaviour is encouraged through the entire study (Opie 2014). The researcher participant submitted relevant documents to the Gauteng Education Department requesting a permission to conduct the study at a specific school.

Further permission was requested from the principal of the research school where assurance of confidentiality, respect, fairness, autonomy and assurance that the school's name and the participants' names would not be made known to the public. The researcher participant gave information letters to the learners who informed their parents of the study, requesting permission for their children to participate in this research. The parents were assured that their children were not in harm's way and their right to withdraw from the study at any particular juncture should a need rise. The Gauteng Department of Education, the participating school principal, parents of the participating school and the University of Witwatersrand ethics committee gave their approval for the study to unfold (see all the relevant documents in Appendix C).

Conclusion.

This chapter discussed the research design, paradigm and methodology. The next chapter deliberated on the results of the data analysed and their discussions.

Chapter 4

Data analysis and presentation of the results.

Introduction:

This study was a qualitative small-scale case study that looked at professional development of one group of Life Sciences teachers from a specific secondary school in Gauteng. All the participants in the study collaboratively interacted, deliberated extensively on the content of meiosis and its transformation applying the five components of the TSPCK framework. The data collection tools for this study included propositional knowledge statements, questionnaires on the interview schedule and videotaping of the entire cycles of the lesson study. The cycle of the lesson study consisted of a goal-setting phase, a planning phase,

enactment of the initial lesson plan, initial post-lesson discussions, enactment of the second research lesson and the final or second post lesson discussion that included completion of a questionnaire and oral interviews.

The purpose was to gather extensive data and analyse it in order to answer all the research questions in this study as follows;

How effective is the Japanese Lesson Study (JLS) as a collaborative professional development activity in regards to;

1.1 Content knowledge of a group of Life Sciences teachers?

1.2 Instructional strategies applicable in relation to meiosis?

2. What are the benefits and challenges, (if any) of using a Japanese lesson study activity as a professional development activity at school level?

Findings from the analysis of the data that was collected from the following sources: video and audio-recorded planning workshops and propositional knowledge statements was used to answer the first research sub-question, which was finding out the content knowledge about meiosis of participating teachers. In section 4.1 below, I describe how I analysed meiosis concept lists from PKS1 and 2 and present the results

4.1. Results of the analysis of meiosis concepts lists in PKS 1 & 2.

The meiosis concepts that were identified by participants were extracted from the PKSs. Tables were used to show the listed meiosis concepts. I used icons as codes to assign the identified concepts to categories. The first category named meiosis sentences not concepts was for those cases when participants would give in depth explanations of a concept but omitting the word that describes the concept for example, “why meiosis occurs” instead of stating “meiosis” and explaining that **meiosis 1** is the behaviour of homologous chromosomes and **meiosis II** the behaviour of chromosomes is the same as in **meiosis I.** However, the genetic composition and the number of chromosomes is not the same.

The second category named correct meiosis concepts was for all correct meiosis concepts, that the participants identified and correctly explained. The third category was the

subordinate meiosis concepts category. This category was divided into two sub-categories namely Concepts needed before studying meiosis and Concepts needed after studying meiosis. **Table 2** Shows categories and icons that were applied in the analysis of PKS1 & 2

Table 2. Icons applied in analysing meiosis concepts in the PKS 1 & 2.

Analysis categories		**Icons**
Meiosis sentence not concept.		♦
Correct meiosis concept.		♠
Subordinate meiosis concept	Concepts needed before studying meiosis.	♫
	Concepts needed after studying meiosis.	♪

4.2 Results from the analysis of PKS 1 & 2.

As explained above, each list was read and each concept assigned a code according to the descriptions in Table 2 above. Table 3 below shows the results.

Table 3: Results from the analysis of PKS1 & 2.

MEIOSIS CONCEPTS IDENTIFIED BY PARTICIPANTS.										
Analysis **codes**	**PARTICIPANT RESEARCHER**		**LIZA**		**BETTY**		**BONY**		**TOMMY**	
	PKS1	PKS2	PKS1	PKS2	PKS1	PKS2	PKS1	PKS2	PKS1	PKS2

Correct meiosis concepts. ♠	Chromosome Chromatids DNA, Genes, Homologous chromosomes, Bivalent chromosomes, Centrioles, Tetrad, Centromere Centrosome Chiasmata, kinetochore Aster, karyokinesis, Eukaryotic, Cytokinesis Meiosis, Interphase, Interkinesis Haploid, Allele,	Meiosis I, Meiosis II, Synapsis, Chromosome Chromatids DNA, Genes, Homologou-s, Bivalent Centrioles, Tetrad, Centromere Centrosome Chiasmata, kinetochore Aster, karyokinesis-Eukaryotic, Cytokinesis Meiosis, Interphase, Interkinesis Haploid	Meiosis, Chiasmata, , bivalent	PK2 not submitted by the participant.	Chromosome, Meiosis, Chromatid, Centromere, Homologous Chromosome, karyokinesis, Cytokinesis,	Interphase, Meiosis, Chromatid, Centromere, Homologous Chromosome, , karyokinesis, Cytokinesis,	Meiosis, Bivalent Crossing over, Homologous-chromosomes.	Meiosis, crossing over, homolog-ous pair, karyokin-esis cytokines-is,	Meiosis, chiasmat-a, homolog ous-chromos ome.	PK2 not subm it-ed by the partic ip-ant.
Total per PKS	**21**	**23**	**3**	**-**	**8**	**8**	**5**	**5**	**4**	**-**
<u>Subordi--nate meiosis concept</u>: Concepts relevant before studying meiosis. ♫	Cell cycle, Mitosis,		_	_	Cell division,	Cell cycle	Gametes,	Cell cycle,	Mitosis	
Total per PKS	**2**	**-**	**-**	**-**	**1**	**1**	**1**	**1**	**1**	
Concepts relevant after studying meiosis. ♪	Mutation, Types of mutation, Non disjunction, Gametogenesis,		Non-disjunction, Down Syndrome, Turner Syndrome and Klinefelter Syndrome	_	Genetic material	_	importance of variation in organisms,	Genetic variation,		
Total per PKS	4	___	4	0	1	0	1	1	_	_

Meiosis sentence not concept. ♦	Mendel's Laws of inheritance .						Phases of meiosis. Where does meiosis occur, Importance of variation in organisms	Stages of meiosis,	Phases of meiosis,	
Total per PK	1	-	-	-	-	-	3	1	1	
Total of PKS 1 & 2	**51**		**7**		**19**		**18**		**06**	

The results from the analysis of the propositional knowledge statements of all the participants as displayed in Table 3 were summarized as shown in table 4.

Table 4. Summary of the results of the analysis of PKS1 & 2.

ANALYSIS CODES	RESEARCHER PARTICIPANT	LIZA	BETTY	BONY	TOMMY
Relevant meiosis concepts. ♠	44	0 3	16	10	04
Concepts relevant before meiosis ♫	02	----	02	02	0 1
Concepts relevant after meiosis ♪	04	04	01	02	-
Meiosis sentence not concept. ♪	01	-	-	04	01
Total	**51**	**7**	**19**	**18**	**07**

4.3. Discussions of the results of the analysis of participants' PKS 1 & 2

The results in Table 3 show that the participants identified and listed very few concepts in their PKS 1 and the number of meiosis concepts listed by the different participants increased in their PKS 2. Some of the concepts were common across all the participants' lists i.e. they were identified by all participants. Examples of such concepts include meiosis, chromosome, chromatid, and homologous chromosomes.

4.4. Analysis of meiosis statements in PKS.

The analysis of propositional knowledge statements was inductive. I read the statements to determine if they reflected correct understanding of the concepts. I then compared the statements with the ones in the expected list which was designed by the researcher participant and approved by the content expert in this study (see Appendix A).

The quality of the statements in terms of the correctness was used to categorize them. Three categories were established. The four categories were **incorrect** explanations of concepts**, correct explanations of meiosis concepts, misunderstandings of relationships between concepts**, and the **simplistic explanation of meiosis concepts.** Simplistic meiosis statements meant those explanations that did not reflect the appropriate science language. Below I present and discuss each category.

4.4.1. Incorrect statements.

By incorrect statements, I mean wrong explanations of a relevant meiosis concept. For example, Bony, incorrectly explained tetrad, as four groups of chromosomes instead of four chromatids involved in meiosis or a pair of homologous chromosomes separating at anaphase 1 (Lawrence, 2011). Betty incorrectly explained interphase as 'a stage in the process of meiosis that happens during the S phase of the cell cycle where DNA replicates and new proteins are formed'. This statement incorrectly because interphase is not a stage of meiosis. In addition, the statement shows that interphase consists only of S phase and responsible only for DNA replication leaving out the components of the interphase, which are G1 check point, G2 check point and M phase. A checkpoint in the cell cycle is a control point where stop and go-ahead signals can regulate the cycle. The M Phase involves the behaviour of chromosomes, cytokinesis a division of the cytoplasm that is made possible protein (Lawrence, 2011). Other preparatory functions occurring during interphase that are growth, DNA replicates producing two copies of chromatids joined by centromere and protein synthesis occurs (Lawrence, 2011).

4.4.2. Correct statements.

Correct statements are those with relevant explanations as applicable in the science world. Results illustrated that four out of five participants explained correctly the concept that homologous chromosomes are similar in genes, size, shapes and the position of the centromere. In addition, results show that three out of five participants identified and correctly explained chromatid, centromere, karyokinesis and cytokinesis. Centrosome structure present in the cytoplasm of an animal cell that functions as microtubules organizing centre and it has a pair of centrioles. Karyokinesis involves the division of the

nucleus in eukaryotic cells. Cytokinesis involves the division of the cytoplasm. Chromatid is a single stand of DNA that compacts a shortened form of DNA (Lawrence, 2011).

4.4.3. Misunderstanding of relationships between concepts.

Some explanations by participants showed that they lacked an understanding of the relationships between some meiosis concepts. For example, Liza incorrectly identified homologous and bivalent as similar concepts and gave incorrect explanations. Fig.1 below shows the PKS 1 statement from Liza.

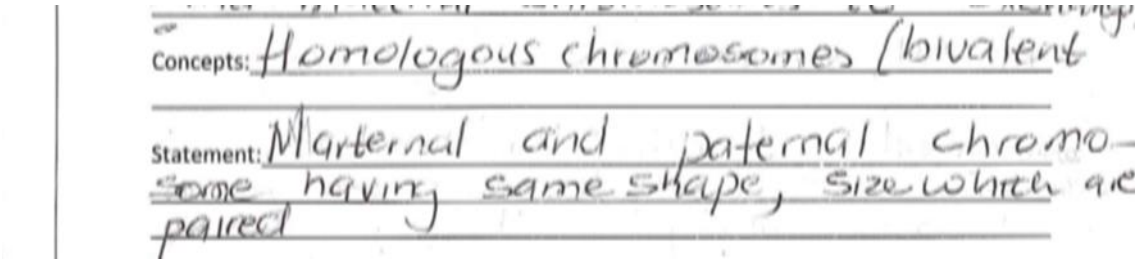

Fig.2. Misunderstandings of genetic terms.

Homologous chromosome and bivalent are different meiosis concepts with different statements. Bivalent is a term that describes a structure when homologous chromosomes lie side by side through a process called synapsis. Homologous chromosomes are chromosomes that are similar in size, shape, structure and may have similar or alternative forms of the same gene. Another example of a misunderstanding of a relationship between concepts involving chiasmata and crossing over is again depicted from Liza's explanation e.g. ('chiasmata' as a 'point where crossing over takes place between chromatids of paternal and maternal chromosomes to exchange genes'). This is a relevant meiosis concept but its explanation involved crossing over. This finding reflects an erroneous idea that chiasmata and crossing over are merged concepts. Chiasmata and crossing over are both relevant meiosis concepts with different meanings. The correct explanation of chiasmata is the point of contact between the non-sister chromatids, which represents the site for crossing over. Crossing over is the physical breakage of certain genes, re-joining the opposite non-sister chromatids. This happens during prophase 1 of meiosis to promote genetic diversity.

4.4.4. Simplistic meiosis statements.

By simplistic meiosis statements I mean the statement does not have the correct scientific language in its explanations. Two extracts from Betty's propositional knowledge statements revealed use of simple explanations that are scientifically incorrect and when transferred to the learners have the potential to promote misconceptions or cause, difficulty in learning relevant scientific concepts.

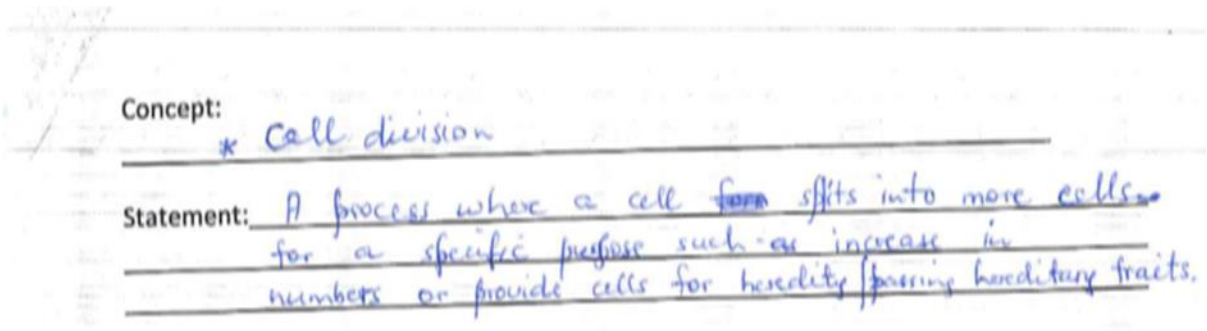
Concept:
* Cell division
Statement: A process where a cell ~~form~~ splits into more cells for a specific purpose such as increase the numbers or provide cells for heredity passing hereditary traits.

Fig.3 Simplistic statement explaining the concept of cell division.

The statement is simplistic in the following ways. Firstly, the use of scientifically appropriate terminology such as 'split'. The word split implies homogenous cell contents, which does not highlight all the different processes that occur during cell division. (Campbell, Reece, Urry, Cain, Wasserman, Minorsky & Jackson, 2008). The word split is relevant in the language of teaching and learning. However, in science, cell division involves the behaviour and movement of chromosomes in meiosis or in mitosis, which commences in the nucleus and it is called karyokinesis followed by cytokinesis, a division of a cytoplasm. (Campbell et al. 2008). Cytokinesis might not occur after karyokinesis. Hence, cell division is either mitosis with cytokinesis or meiosis including cytokinesis with different purposes, which the participant generalized. Common events between meiosis and mitosis occur only in the interphase and they include growth, development, DNA replication, protein synthesis and duplication of chromosomes. (Campbell et al. 2008). After interphase in the M phase of the cell cycle, there is evidence of the different purposes of either mitosis with cytokinesis or meiosis with cytokinesis as explained in the following paragraph.

Betty also generalized the purpose of mitosis and meiosis, which is incorrect explanation by stating in her statement depicted in fig.3. as in the 'more cells'. This is incorrect because the difference between mitosis and meiosis is that mitosis conserves the number of chromosome sets (diploid). Whereas, meiosis reduces the number of chromosome sets from diploid to haploid (Campbell et al. 2008).

Betty continues to explain that cell division 'provides cells for heredity/passing-hereditary trait'. This statement is simplistic because both meiosis and mitosis transfer genes from one cell to another not from generation to generation in different organisms. However, transfer of hereditary units or genes happen differently in various modes of reproduction, which involve asexual and sexual reproductive processes. For example, in most forms of asexual reproduction all of the cells are produced by mitosis, a rapid process, which results in offspring whose genes and inherited traits are identical to those of the parent but in sexual reproduction there is fusion of gametes to form a single zygote. Meiosis forms the gametes,

the genes in these gametes are genetically diverse because of crossing over and independent assortment at the metaphase plate.

Therefore, meiosis produces cells that are genetically different from the parent cell and from one another (Campbell et al. 2008). Another example of a simplistic statement from Betty PKS1 is shown in Fig 4 below.

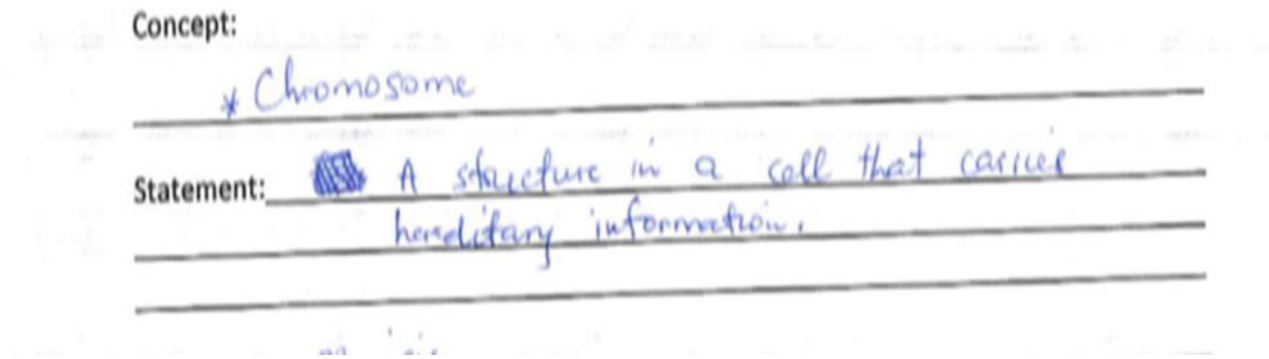

Fig.4. Simplistic statement explaining what a chromosome is

This is a simplistic statement because it is not giving a precise scientific explanation of the structure. This may promote a number of misconceptions. For example, one of the misconceptions stated by Dikmenli (2010) is that students have this perception that a chromosome always has two chromatids during cell division. Therefore, it is important to eradicate the misconception by stating specifically that either a chromosome can be double or single stranded, compacting DNA around proteins called histones. (Campbell et al. 2008). When omitting the exact location of the chromosomes as depicted in the above statement a number of misconceptions and erroneous ideas may be promoted. For example, students may assume that chromosomes are scattered throughout the cell. (Dikmenli, 2010).

The statement in Fig.4 came directly from a textbook. This attests to the study by Lewis et al. (2000a) that some textbooks are the source of certain misconceptions. Therefore, simplistic explanations from both the teachers and learners' textbooks are the source. The simplistic statements do not help in the scientific understanding of relevant concepts. When teachers rely solely on the textbooks for teaching and learning, this implies that they will continue to pass these simplistic statements to the students.

4.5. Results from the analysis of workshop transcripts.

Three workshops were organised to do in depth deliberations on the meiosis content knowledge concept by concept. The workshop deliberations were all recorded and transcribed. Insights from the analysis of the workshop transcripts were then grouped into themes as follows: Meiosis concepts that participants did not know, incorrect explanation of meiosis concepts misconceptions or errors and partially correct explanation of meiosis concepts.

4.5.1. Meiosis concepts not known by the participants.

The analysis of the workshops transcripts illustrated that all the participants did not know the explanations of certain meiosis concepts that included meiosis I, meiosis II and cell division concepts. In this section, I discussed three meiosis concepts even though there are other concepts that participants did not know. I chose to use these three concepts as examples because cell division was discussed in the results of the analysis of PKS 1 in 4.2.3 and its incorrect, simplistic explanation continued to emerge in the workshops that involved articulation of meiosis concepts and their explanation. This attested the results of meiosis content knowledge gaps as depicted in the PKS. In addition, the choice to use meiosis I and II was the fact that all participants teach about the activities that transpire in meiosis I and II, but they omitted the explanations of these concepts in their PKS.

All the participants including the researcher participant described meiosis 1 as the cell division of a single cell into four haploid cells that are genetically different. The correct explanation of meiosis 1 concepts is that meiosis 1 is the behaviour of homologous chromosomes. All the participants excerpt the researcher participant explained meiosis II as process where the behaviour of chromosomes is similar to mitosis. Through collaboration we agreed to a modified statement that described the behaviour of chromosomes in meiosis II as the same as the behaviour of chromosomes in mitosis. However, the genetic composition and the number of the chromosomes is not the same. A result, which showed that through collaborative deliberations on meiosis content knowledge new understandings of meiosis concepts and their statements, emerged. In another example only one participant out of the four participants including the researcher participant, Betty identified cell division as a meiosis concept in her initial propositional knowledge. However, its explanation was incorrect as shown as one of the examples in 4.2.3. The correct explanation of the cell division concept is that it is the division of a cell or cell contents, which will be meiosis plus cytokinesis or mitosis and cytokinesis

The extract below shows direct expressions from the respective participants; hence, the use of inverted comas and the analysis code are highlighted in red and in brackets in every articulation with a reason for its use. NB: the identified participants using pseudonyms directly utter the statements in the inverted comas. The statements in the inverted comas were not altered, they might have language errors).

Content expert. "Cell division". (She was the first person to state cell division).

Researcher participant: "cell division lets explain this meiosis concept" (incorrect, because cell division is not a meiosis concept but meiosis is a concept under cell division)

Liza: "haploid." (Incorrect, meiosis leads to a haploid number of chromosomes).

Betty: "meiosis is one form of cell divisions there are many types of cell divisions, and meiosis is one of them", (incorrect because there are not many cell divisions excerpt mitosis plus cytokinesis or mitosis plus cytokinesis).

Bony: "cell division is divided into mitosis and meiosis". (Incorrect explanation, because cell division is not mitosis and meiosis. It is meiosis plus cytokinesis or mitosis plus cytokinesis).

Timmy: "ja, we have a cell, and a cell as it matures, ja because of growth, (mitosis happens so that the cell can grow, repair and replace other cells. We come back to meiosis happens in other cells for the reason to give rise to gametes". (Incorrect, the participant explained the significance of mitosis, meiosis happens in gonads and one of its significance is gametogenesis).

(The content expert explanation is partially correct when explaining the division of a cell or cell contents to form two daughter cells because during meiosis four daughter cells are formed. However, her summarizing statement that cell division is the division of a cell or cell contents, which will be meiosis plus cytokinesis or mitosis and cytokinesis was the one collaboratively agreed upon as new meiosis content for all the participants).

The results from the above-illustrated extract and analysed transcripts showed content knowledge gaps. These results attested to the need for this study because transcripts depicted that in-depth deliberations through collaboration by the participants and the content expert led to modified statement that described the behaviour of chromosomes in meiosis II. Evidence thereof extracts from the transcripts of the workshops. This showed that through collaboration the content expert corrected explanations of cell division as depicted by the above articulation.

The next extract shows through collaboration a misconception that meiosis II is similar to mitosis was modified to new learning:

Example number 2:

Researcher participant: "now, can we really say meiosis two is similar to mitosis".

Content expert: "we can re word".

Researcher participant: "okay, lets re word".

Content expert: "the behaviour of chromosomes is the same. The behaviour of chromosomes in meiosis two is the same as in mitosis"

Researcher participant: "ah… The behaviour of chromosomes in meiosis two is the same as in mitosis. But not the process and the structure rather the genetic composition and the

number of chromosomes is not the same" (this was the explanation of meiosis II that was collaboratively modified and agreed upon).

4.5.2. Incorrect understanding of meiosis concepts.

(i) The position of the centromere.

Participants in this study had an incorrect understanding that the position of the centromere is always midpoint. Therefore, the researcher participant facilitated the new content knowledge that involved three positions of the centromere. From the discussions, it was clear that the source of this misunderstanding was the textbooks that are used at school level.

ii) Incorrect understanding of chiasma, crossing over and homologous chromosomes.

Liza had incorrect understandings of the concepts of homologous chromosome, chiasma and crossing. What is key to note is that in the propositional knowledge statements, Liza had correctly identified and explained these concepts but the workshop transcripts had shown that actually **Liza** had a misunderstanding of crossing over as shown in Figure 1 and the extract that follow.

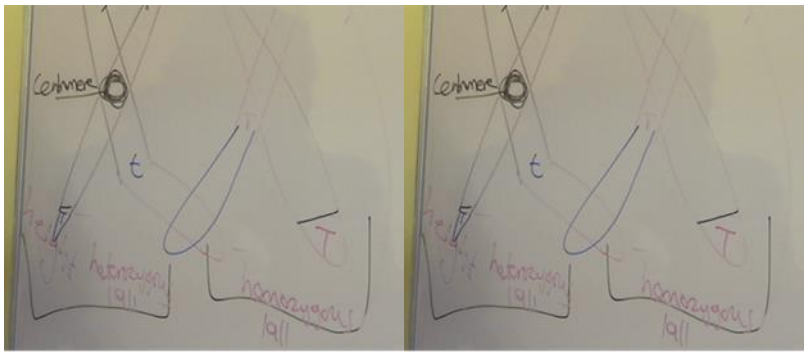

Fig.5. Incorrect representation explaining crossing over.

Liza: "but the concept chiasma is a point at which the chromatids of the homologous pair of chromosomes attach during crossing over. A point is where. This point (making a cross with her fingers) this point it is called chiasma". (Partial correct in relation to chiasma. chiasma is a structure formed by homologous chromatids in prophase 1 of meiosis; it is a site for crossing over because crossing over might not occur).

Content expert: "This point". (Content expert pointing at chiasma in the drawing).

Liza: "yes that point. Because the homologous chromatids (note incorrect use of the word homologous. Chromatids are never described as being homologous) the point that they

meet is called the chiasma". (Correct understanding of chiasma, although it is the contact point for non-sister chromatids of the homologous pair).

Researcher participant: "you are agreeing with one another. It is true". **(Both the participant and the content expert pointed at the diagram in Fig. 5, because chiasmata /chiasma is a structure point of breakage at the end point of gene, and a researcher participant attempts to show that there is agreement in relation to chiasma** (correct explanation of chiasma).

Liza: "that process is crossing over". (Incorrect statement, which showed misunderstanding of chiasma and crossing over)

Content expert: "that is where we are not agreeing. Crossing over is the actual, the process where there is the breakage". (Correct statement for crossing over).

Liza: "after crossing over, after exchange of genetic material, after, the will be breakage. Crossing over is a process, which process, when they exchange genetic material at which point, at chiasmata after that exchanging of genetic material. They break" (incorrect answer, showing that the participant needed more clarity).

Content expert: (comes to the white board to argue her statement) "each chromatid has many genes. It occurs where the genes meet. At the ends of each gene". (Correct explanation of crossing over).

Content expert: "let me Explain. "Chiasmata, let me be specific it can occur in the genes quoting for the colour of the eyes. Let me continue. Chiasmata will occur that is point of breakage at the end point of gene, followed by the crossing over, that is the actual breakage where genes are exchanged re-joining the opposite non sister". (Correct answer for chiasma and crossing over collaboratively agreed upon by all the participants).

The results from the above extract show an incorrect understanding of crossing over that **Liza** articulated that did not come out in the PKSs. Therefore, this study workshops allowed the incorrect representation of crossing over, chiasma/chiasmata, crossing over and centromere to surface and to be clarified. The correct explanations of the identified meiosis concepts were that chiasmata /chiasma is/are a structure point of breakage at the end point of gene. Crossing over is the actual breakage of genes at the chiasmata. Homologous chromosomes are similar in genes, size, shapes and the position of the centromere. Centromere a region on a chromosome at which the kinetochore assembles and at which a chromosome becomes attached to the microtubules of the spindle during meiosis. Centromere is located in located in three different regions on the chromosomes.

Based on the position of centromere and length of chromosomal arms, the chromosomes are classified into three groups namely: telocentric chromosomes, acrocentric

chromosomes and metacentric chromosomes. In telocentric chromosomes the centromere is located at the proximal end (tip) of the chromosome. In acrocentric chromosomes the centromere is positioned at one end of the chromosome in such a way that it produces a very short arm (p) and an exceptionally long arm (q). metacentric chromosomes have the centromere location at the centre. The deliberations on the concepts also revealed a misunderstanding of the concept homologous chromosome. The same process of having the content expert to explain and the discussion by the whole group was followed until a similar understanding was reached.

The results presented above shown the importance of doing workshops in a JLS that are focussed on the discussion of content. Oral discussions of concepts where every participant is given a chance to present his/her understanding of the concepts provide opportunities for misunderstandings to surface and to be clarified collaboratively. Hence, the JLS can build content capacity in teachers.

4.6. Discussion of the results from the analysis of PKSs and from workshops.

The analysis of PKS showed that while the participants were able to list the concepts of meiosis, their respective lists were not comprehensive. They left out a great number of concepts. Some of the statements describing the concepts were wrong and there was evidence of misunderstanding of the relationship between concepts such as the relationship between bivalent and homologous chromosomes and chiasmata and crossing over. In addition, some correct meiosis concepts were incorrectly explained. Therefore, the analysis of PKSs showed that the participating teachers had content gaps. The analysis of workshop transcripts provided further evidence that participants had content gaps as there were some meiosis concepts that were not known by the participants. Some participants also gave incorrect explanations of meiosis concepts.

I did this research to investigate the benefit of the JLS approach, as a collaborative professional development activity, effective in improving the meiosis content knowledge of a teacher. The results depicted that there was an improvement in the listing of relevant meiosis concepts and their explanations in PKS2 when compared with PK1. Therefore, I can say that the JLS as undertaken in this study was effective in firstly, identifying teachers' content knowledge gaps and secondly, identifying teachers' content misunderstandings. The JLS also provided opportunities for 'filling" in of the teachers' content gaps and clarifying the misunderstandings.

4.7. Results from the analysis of the research lessons.

The post lesson discussions were meant to deliberate on the observed lessons to bring out the strengths and the weaknesses of the lesson and what can be improved. Below I present what came out of the lesson analysis using the TSPCK components and transcripts for reinforcement. I will end the section by outlining what the results mean with reference to RQ 1.2.

4.7.1. Prior knowledge.

Results depicted awareness by the presenter of the lesson that learners bring prior knowledge to class. However, the prior knowledge was assumed. The teacher did not find out what learners knew. **As reinforced by the following extract:**

Content expert: "I agree, why you started with chromosomes". (Prior knowledge).

Observed teacher: "I wanted the learners to recall because they learnt about chromosomes in grade ten when they were learning about mitosis. Therefore, I wanted to move from what they know". (Prior knowledge)

Content expert: "if we go to the TSPCK, she started about the (prior knowledge), which is key but you did not find out about what they know. A critical opportunity that you missed you did not find out if they knew what a chromosome is. Weak point is that you did not consolidate".

This outcome led to the design of the second research lesson that the teacher needed to use a teaching strategy that would promote in depth discussions that would forth the extent of the students' knowledge of a chromosome. The results of the teaching of the second meiosis lesson show use of extensive questions at the onset of the teaching of meiosis lesson about the student prior knowledge involving the structure of a chromosomes. Therefore, the results show that the JLS approach afforded all the participants the opportunity to be aware of learners' prior knowledge and also how to bring the knowledge out from the learners and deliberate on it. **Evidence of this results about the prior knowledge component is the following extract from the transcripts:**

Betty: "I liked that moment you told them that something is wrong but you did not tell them and they went back on their own to search for it. I love the way the lesson started. (Prior knowledge) I do not start meiosis the way you started it but the zooming in on the chromosome and getting it thorough." This is also evidence that other participants were learning about alternative ways of introducing the lesson on meiosis.

4.7.2. Curricular saliency.

Results reflected that all the participants had tension between giving too little and too much information when teaching about the phases of meiosis as illustrated during the initial meiosis lesson. In addition, the results showed that the observed teacher in the teaching of the first meiosis linked it minimally to other topics. The other participants had similar difficulty on how to link meiosis to other topics too. Therefore, all the participants collaboratively agreed that the teaching of the second meiosis lesson should include related topics such as variation. **Two extracts are examples that depicted curriculum saliency in the second meiosis lesson:**

Example 1: **Observed teacher 2:** "The crossing over form genetic variation happens genotipically but its results in the offspring happen phenotypically. Variation is a chapter on its own; therefore, we are going to come back to it, types of variation that we have, yes student"?

Student: “continuous and discontinuous variations”.

Observed teacher 2: “ja will come back to this because our purpose is the behaviour of the homologous chromosomes”. (making students’ aware).

Example 2:

Student: “the bivalent chromosomes arrange themselves at the equator, the arrangement is called random assortment, which introduces genetic variation into the gametes”.

Observed teacher 2: “ja will come back to this because our purpose is the behaviour of the homologous chromosomes”. (making students’ aware).

These results attest to the fact that the JLS approach afforded all the participants the support and the confidence to overcome their respective fears on what is too little or too much meiosis content knowledge including its teaching meiosis. Therefore, attesting to researches that when teachers are involved in professional development activities that allow them to be active participants as in the JLS approach in this study, their respective content knowledge including its teaching modifies (Doig & Groves, 2011).

4.7.3. What is difficult to teach?

Evident from the results of the teaching of the meiosis lesson was the following. Firstly, the observed teacher 1 knew that meiosis terms are difficult for learners to understand. Secondly, the observed teacher 1 understood that meiosis content knowledge is abstract and that poses a challenge for the learners to conceptualize. However, the results showed that the delayed response to rectify student’s errors when teaching meiosis terminology led to the students building wrong models.

This is an example of an extract that depicted incorrect explanation of tetrad.

Observed teacher: “ok what is your definition of tetrad”?

Student: “my definition of tetrad is a group of four chromosomes”.

Observed teacher: “ok did you hear that guys? What did she say”?

Student: (as a collective they answer) “group of four chromosomes

The correct explanation of tetrad is that it is four chromatids or two sets of chromosomes during bivalency. As a result of this the collaborators discussed that the teaching of meiosis lesson should involve consolidation timeously to ensure that learners understand and errors are rectified. The results of the teaching of the second meiosis lesson showed that the learners had a challenge also with “dyad” and “tetrad” but in this phase the observed teacher and the teacher guided the students to a correct answer as indicated in the following extract:

Observed teacher 2: "Okay people we are all struggling with dyad and tetrad, all of you are struggling with tetrad and dyad (she puts a power point of terms) and reads, dyad chromosome is made up of how many chromatids)"?

Students: "of two chromatids"

Observed teacher 2: "ja good, it is made up of two chromatids. So, homologous chromosomes are made up of how many chromatids"?

Students: "four".

Observed teacher 2: "now out of these two words dyad and tetrad **(pointing at the PowerPoint)** let me put a picture, okay here is the picture, where is the marker? Out of these, I am going to put a circle and say section A and say this is B. Using these words 'tetrad' and 'dyad' so where are you going to put these two words? You have A or B.

This implies that the teaching of the meiosis lessons offered all the participants an opportunity to further engage on the meiosis concepts and their explanations since during the workshops the results showed that the participants themselves struggled with "dyad" and "tetrad". Therefore, the JLS implementation phase continued to allow all the participants to engage in meiosis content knowledge including its teaching.

4.7.4. Representations including analogies.

Results displayed that the collaborators favoured the use of dictionaries at the inception of the initial meiosis lesson to allow the students to know terminology. Furthermore, the use of modelling clay to build the terms and phases of meiosis promoted conceptualization because abstract concepts became visual. However, the inability of the observed teacher 1 to correct the explanation of the "tetrad" when learners engaged with scientific terms led to an incorrect representation of the concept in the respective learner's model as shown in Fig.6.

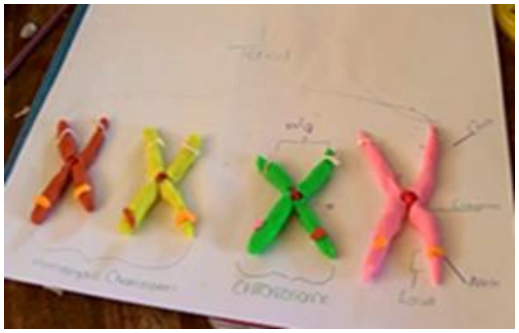

Fig. 6. Model depicting incorrect tetrad concept.

The results indicated that in the teaching of the second meiosis lesson the observed teacher 2 ensure that all the students in their different groups corrected their errors before peer assessment. In addition, for consolidation there was evidence of the groups rotating clock wise to assess each other's models per phase and individual member per group reported it to the entire class about each phase of meiosis.

4.7.5. Conceptual teaching strategies.

Individual task, group work, comparing of the models task (peer assessment) and questioning were the three teaching strategies identified in the results of the study. The individual teaching strategy illustrated that the students used the glossary from their textbooks and Henderson's dictionary, which was written work and they took turns to report on their respective terminology and phases of meiosis models. Comparing of the models task: (peer assessment) was the instructional strategy that required the learners to build models of each phase as they unfold in meiosis I and II and compare them in their various groups whilst the observed teacher moved from group to group ascertaining whether relevant scientific language was applicable and if the students know the process of meiosis. Questioning conceptual strategy that was applicable through the teaching and learning of meiosis to bring to the surface students misconceptions, errors, provoke them to think deeper for solutions and to ascertain their understanding.

Group work conceptual teaching strategy involved a Think-Pair and Share in groups consisted of four members that were allocated specific roles to build models, assist with reporting to the entire class, enabled peer assessment as a mechanism to eliminate students' misconceptions within the social context provided by the respective groups. **For example, extract from the transcripts of the teaching of both meiosis lessons attesting that they promoted conceptual teaching.**

Content expert: "Overall, I liked the entire process you put learning into the hands of the learners from the beginning to the end. Let's get overall feedback from other participants".

Bony: "no, I love the lesson it was great. When you are going into groups, you know groups can be chaotic, what the other groups are doing are they preparing for you to come to them"?

4.8. Discussions of the results from the analysis of research lesson reviews

I investigated the extent of effectiveness of the JLS as a professional development activity, in improving instructional strategies applicable to meiosis. The results in relation to this research question emanated from the analysis of the initial videotaped meiosis lesson, transcripts from the initial post lesson discussions, results from the second research lesson and second post lesson discussions. Overall results showed, that there was an improvement in both the content knowledge and the instructional strategies from the first to the second research lesson. This result can be attributed to the collaborative review of the first research

lesson which had looked at both the weak areas and good aspects depicted in the initial lesson. For example, difficult aspects in relation to the teaching of meiosis, which involved terminology and including it microscopic representations, were identified and discussions on how to promote their conceptualization by the learners collectively decided.

Below is one example of an extract that reinforce how the use of modelling clay during the teaching of both meiosis lessons influenced Bonny's thinking with reference to her plans for her future teaching of meiosis: **Bonny** stated, "what I have benefited about teaching here was the use of models it was very beneficial for the students. Because comparing where I am teaching, we do not have apparatus and all those things. When we teach meiosis it becomes difficult especially when they are not using models they cannot see what is happening, so, it becomes a challenge." (Clay model representation).

Therefore, the JLS approach in this study afforded all the participants an opportunity to respectively look into their own practice that involved planning, teaching, use of representations and instructional strategies that promote the learners understanding of meiosis. The overall results in this phase of my study showed a need for balance between content knowledge and instructional strategies applicable to its teaching so that learners may understand as it is stated by Shulman (1987) PCK. For example, the results of the second research lesson showed a cell cycle that was not completely correct. However, the observed teacher told the students about the error and continued to utilise it to in relation to meiosis. One of the participants in the analysed transcripts of the reflection session confirmed the importance of a teacher being a content expert. For example, **Betty:** "I am definitely sure that there are teachers who do not know about cell cycle and they don't teach it so what I have learnt is that the teacher needs to go outside the textbook and know more so as to make the learners aware even if you are not teaching it". (Teacher's misconception).

The results also showed extensive improvement in curriculum saliency as evident in the practice of the second research lesson since the other participants had prompted the observed teachers to make reference to other topics related to meiosis during practice. Therefore, the JLS approach satisfactorily improved the practice of the respective participants in this study as the transcripts of the reflection phase of this study. **Content expert (chairperson of second post lesson discussions) and Betty affirmed this:**

Content expert: "I still remember that in your enactment of the second lesson you were able to link phase of meiosis to other topics like genetics, mutation."

Betty: "not to be scared to introduce a new topic beforehand that is coming whilst you are dealing topic gametogenesis so that when you teach reproduction learners cannot say but we are with that topic why are we going back".

Conclusion

The JLS professional development activity provided the participants with the platform to deliberate on the meiosis content knowledge and its teaching. The evidence there of was depicted in the analysis of the transcripts of the three workshops, and the observations of the two videotaped meiosis lessons which showed a satisfactory improvement in the teachers' meiosis content knowledge including its teaching. These results attest to researches by Doig & Groves (2011) and Ono & Ferreira (2010) that the JLS as a professional development activity provides the teachers at school level with a support system in form a community of inquiry. The community of inquiry consists of a group of individuals that have the same goal according to the respective contextual issues and they collaborate, interact and reflect to attain it.

4.9. Results and discussions of the results from the analysis of the questionnaires and the focus group interview.

Questionnaires were administered during the last phase of the second post lesson discussions. The completion of the questionnaire was followed by a group interview. The purpose of this phase was to gather information from the participants of the benefits and challenges (if any) of the JLS as they had experienced it. The information was used to answer the second research question, which is: **What are the benefits and challenges, (if any) of using a Japanese lesson study activity as a professional development activity at school level?** The results from the analysis of the questionnaire and interview transcripts were clustered into two themes that are the benefits and the challenges of the JLS approach in this research. Each theme results were illustrated under the JLS cyclic phase that are goal setting and planning phase, teaching of both meiosis lessons (implementation phase) and the two post lesson discussions (reflection phase). There is use of extract from the transcripts in the results and their discussions for reinforcement.

4.9.1. Results depicting the benefits of the JLS approach.

(i). Benefits of the JLS approach.

Results were: Firstly, four out of five participants who were present during the post discussion phase to discuss the **benefits and challenges, (if any) of using a Japanese lesson study activity as a professional development activity at school level** indicated that the goalsetting planning phase enabled them (participants) to be conscious of their lesson planning skills. Secondly, the JLS approach improved their respective meiosis content knowledge, eliminate their individual misconceptions in relation to meiosis concepts and their statements. Thirdly, the JLS approach established a culture that enabled the teachers to assist one another in content knowledge and its teaching. Fourthly, the results also showed that the participants from their admission as depicted in the illustrated excerpts

admitted to gaining relevant teaching strategies and representation that they intend to use in the near future when teaching meiosis.

The extracts from the transcripts confirmed the benefits of the JLS approach in relation to the improvement of their respective planning, meiosis content knowledge and peer support.

Example no1:

Betty: "well with the interactions. I remember coming here for the first meeting, the planning I came here not knowing what to expect through that it became clearer that. You know I had a brief meaning that it is about planning together.so when we interacted and deliberated on the concepts there is something that I learnt, a very short thing that meiosis is the behaviour of chromosomes (Content knowledge). You know it just meant everything. It summarised everything about meiosis that is what the learners are supposed to know that the chromosomes will be doing this and this. This made it so easy for me. You know that session one gained a lot because we hardly ever do this sit down as Life Sciences teachers and talk there are certain things that you tend to forget and certain things that you take for granted but if you sit down and talk then you come forward and you realise that I am being careless in my classroom and in my teaching there are certain things that I bypass or assume that the learners understand in my planning. That is what I enjoyed about that planning session". (Content knowledge).

Example no 2:

Timmy: "I have noted the very one that mom is saying. Mine starts with the cell division before this process it was difficult for me to differentiate between the cell division, cell cycle and where and how meiosis fit in those". (Content knowledge).

Example no 3:

Bony: "this thing of grouping us together as educators it is very beneficial so that we as educators can point out the errors that are there in the textbook and the errors that we as educators are doing." (Misconceptions).

Evidence that practice in JLS approach in this study afforded the participant an opportunity to acquire and improve satisfactorily their respective instructional strategies and representations. Evidence thereof was from the transcripts by

Betty: "I liked that moment you told them that something is wrong but you did not tell them and they went back on their own to search for it. I love the way the lesson started. (Prior knowledge) I do not start meiosis the way you started it but the zooming in on the chromosome and getting it thorough."

Another improvement in instructional strategies cited by

Timmy "I realized that there are number of teaching strategies used in this program that can be useful to me in my own teaching of learners because I am one educator who likes giving information to learners but with this. One, I realized that I might be giving misconceptions. (Conceptual teaching strategies). True learners themselves there is something that they know. Therefore, why don't you let them find it on their own, come up, and sum it together? So, to me this has been very fruitful".

These results attest to those of the study executed by Ono & Ferreira (2010) in South Africa using a JLS approach and the participants confirmed that it gave them ideas on how to design tasks and the use different skills when teaching. Furthermore, the planning of the lesson in a group enables all teacher to understand policy documents and assessments standards. The JLS approach used concurrently with the TSPCK components made the participants aware about linking of meiosis to related topics, which was not done according to their own admission as depicted in the transcripts. These results confirm Shulman (1987) idea that teachers need to have content knowledge but they also need to have the ability to transform it to a point that learners understand it.

(ii). Challenges of the JLS approach in the teaching (implementation phase).

Three sets of the results are evident in relation to the challenges of the JLS approach in the teaching of meiosis lessons. The first challenge was that the participants could not physically observe their peers in the real classroom situation as they were teaching the meiosis lessons. Classroom observations could not be done because it is unlawful to conduct research during teaching time.

Classroom observations could have been done over the weekends and during holidays. However, this could not be feasible because students at the research school attend an intensive compulsory programme organized by the Education Department. Therefore, this led to the teaching of meiosis lessons to be videotaped and the peers to observe the two respective video recordings. This challenge brought forth discussions about observation of teachers by the peers and the community as it happens in the original JLS approach.

These are the extract from the transcripts about observation by peers:

Researcher participant: "According to the original Japanese Lesson Study when the teacher is there teaching the other collaborators are there observing him or her in the classroom and there is a video recording". I want to know is that possible in South Africa for a teacher to be observed and videotaped?

Betty: "may I come from another angle. "Yes being observed might be uncomfortable yes, you are protecting your territory, unless you are confident about what you are saying, not that I don't agree with you. On the other hand, if you are still inexperienced, you will say yes, I will make mistakes but in the end, I will gain and become better". The second challenge included the aspect of time because in South Africa there are no professional development activities during the contact time. However, a participant came up with suggestions to resolve the issue of time for classroom observations that are shown in the **following excerpt:**

Timmy: "It's just that mom I thought you were talking about the issue of time. However, it is possible if at a particular school you will be having the same partner when presenting a lesson that would come and become easier. I think the learners at that school the learners will know that the teachers in that schoolwork as a team they understand the content in the very same way so that we are not judged that this teacher is better than that teacher is what is important is the delivery of the content."

Discipline and classroom management were an issue that evident during the teaching of the second meiosis lesson in this study when the observed teacher 2 stopped execution of the second meiosis lesson citing learners undisciplined behaviour. **Betty's extract attests to the different learners' behaviour during the teaching of meiosis lessons**

Betty: "Now there is also there is another dimension to being observed the learners they respond differently when they are with the teacher they know to when they are with a different teacher. I saw the learners when observed teacher no1 was teaching they were very heavy on her than when they were taught by observed teacher no2. They were not responding in the way that they were responding to observed teacher no2. To the observed teacher no 2 one of them even said you have not called me."

The analyses of the excerpt by **Timmy** brought forth a solution, which involved that peer teaching because it encapsulates both classroom observations and the discipline since learners will be used to different teachers in a specific subject engaging with them.

4.10. Discussions of the results in relation to the JLS approach

The JLS approach as a professional development activity afforded the participants and the researcher participant an opportunity to acquire collaboratively new meiosis content knowledge, eliminate their respective meiosis misconceptions, correct meiosis concepts and their statements during the goal- setting and the planning phase. Furthermore, the researcher participant through the JLS approach created another avenue for the other participants in relation to the way they plan their lessons using the five components of TSPCK.

In addition, the JLS approach afforded the participants in the teaching of the lessons opportunities to look into their own teaching and improve it according to the feedback. The post lesson discussions of the JLS approach afforded all the participants to reflect on the meiosis content knowledge, its practice and to come up with modifications to improve their teaching of meiosis.

The use of the TSPCK as a framework made the JLS approach more structured and clear because all the participants knew what was expected from them in each phase.

Conclusion.

In is chapter results were presented and discussed. In the next chapter, I summarised the results of this study, answered the research questions, research limitations, implications and presented my reflections on the study.

Chapter 5

Summary of the results, answering research questions, implications, limitations and reflections.

Introduction.

This chapter summarised the results of this study, discussed the answering of the research questions, research limitations, implications and presented reflections.

5.1. Results of the study;

- Teachers forming the community of inquiry in this study became aware of meiosis concepts and knowledge gaps.
- Teachers' errors emerged and they were deliberated upon up until the relevant scientific knowledge was conceptualized.
- Evidence of new instructional strategies and representations materialized to approach the teaching of meiosis content knowledge.
- Introduction of a new culture that teachers can use to assist one another in content knowledge and its teaching.
- The teachers were made aware of the content knowledge aspects that they had taken for granted.

5.1.1. Teachers forming the community of inquiry in this study became aware of meiosis concepts and knowledge gaps.

This result was evident from the results of the analysis and comparison of Propositional Knowledge Statements 1 and 2. The number of concepts listed showed a marked increase in PKS2In addition, the results showed that when the participants provided statements explaining the meiosis concepts in their individual Propositional Knowledge Statement there was the evidence incorrect explanations of concepts, misunderstandings of relationships between concepts, and the simplistic explanation of meiosis concepts. However, when the participants completed the statements explaining the meiosis concepts in the second Propositional Knowledge Statements was a slight improvement. Therefore, these results edify researches by Leu (2004) and Hassard & Dias (2009) who state that teachers need to be active participants in the professional development activities that are characterised by collaboration and willingness to learn.

5.1.2. Teachers errors emerged and they were deliberated upon up until the relevant scientific knowledge was conceptualized.

Results depicted numerous meiosis content errors emanating from the teachers. These errors were rectified collaboratively by discussions during the workshops from the rest of the participants and the content expert up until a correct meiosis understanding was attained. For example, the errors identified were The results that illustrated the meiosis concepts were not known by the participants that involved meiosis being a behaviour of chromosomes instead of a cell division as stated by the participants. The results which showed incorrect understanding of meiosis concepts involved the position of the centromere and the incorrect representation of crossing over.

These results confirmed findings from other researches by Rollnick & Mavhunga (2014) and Yip (1998) who comment that when science teachers lack content knowledge and the results there of lead to the poor performance of learners in Science. Because when teachers lack content knowledge they become sources of erroneous scientific ideas, which they transmit to the learners when teaching.

5.1.3. Evidence of new instructional strategies and representations materialized to approach the teaching of meiosis content knowledge.

The instructional strategies used in the teaching of the research lessons involved questioning, individual work, group work and peer assessment. Results in relation to the application of these identified instructional strategies were ideal because they enabled the learners to be active participants in their own learning and in charge of their own learning under the guidance of a competent individual (Vygotsky, 1978). The representation implemented involved the diagram representation of a cell cycle to teach the phases of meiosis within it context to promote learners understanding. The use of this representation is advocated to by Smith & Kindfield (1999) and it is stated in the Department of Basic Education. (2016). Diagnostic Reporting on Grade 12 Life Sciences results. However, the results indicated that the participants did not teach meiosis within the cell cycle.

Those that used the diagram representation of a cell cycle to depict its M phase as mitosis, is not correct. The other representation involved the use of dictionaries at the onset of the teaching of meiosis. The use of the dictionaries helped the learners to conceptualize the meiosis scientific language that is described as difficult by learners themselves and the teachers. This fact has been confirmed studies by Dikmenli (2010), Smith & Kindfield (1999) and the Diagnostic Reporting on Grade 12 Life Sciences results by DOBE (2016).

The results illustrated the use of modelling clay to represent the behaviour of chromosomes in the different stages of meiosis, a representation condoned as ideal by Smith & Kindfield (1999) and the participants in the study. Smith & Kindfield (1999) encourage the use of

modelling clay to demonstrate the behaviour of chromosomes during the phases of meiosis because it is difficult for the learners to understand because it is an abstract concept.

5.1.4. Introduction of a new culture that teachers can use to assists one another in content knowledge and its teaching.

It is evident from the results that the participants attend workshops that are devoid of the culture where teacher support each other by designing a lesson plan as a group and take turns to teach it whilst observed by the peers.

The current professional development activities are clustering of teachers per subject that involve lecturing by the cluster leaders that continue to neglect the content knowledge problems of the teachers as illustrated in the results of PKS1 and the results for transcripts of the workshops All the participants indicated the need for professional development activities that allow teachers to collaborate and interact about the content knowledge and it teaching to a point that learners understand it as confirmed by the researches of Kriek & Grayson (2009), Gess-Newsome (1999), Mokhele (2014), Rollnick & Mavhunga (2014), Rollnick & Brodie (2011) and Shulman (1986).

5.1.5. The teachers were made aware of the content knowledge aspects that they had taken for granted.

The results from the analysis of the post lesson questionnaires and the transcripts showed the following. Firstly, some of the participants admitted to not planning before going to classroom due to experience. Secondly, not paying attention to how they speak when they teach, teaching for examination purposes, omission of certain aspects of content knowledge when teaching due to time frame or lack of content knowledge. For example, teaching meiosis out of the cell cycle context. Thirdly, taking for granted the learners prior knowledge that may hinder learning. For example, learners understanding of a chromosome before the teaching of meiosis. The fourth aspect is that teachers take for granted the reflection phase to ascertain what work or did not work in their teaching of a certain topic and how they intend to reinforce or rectify to promote understanding.

The participants in this study were made aware of their respective meiosis content knowledge gaps including its teaching by the use of specific components of the CoRe concurrently with the TSPCK components as depicted in the cyclic phases of the JLS approach.

5.2. Answering of the research questions.

How effective is the Japanese Lesson Study (JLS) as a collaborative professional development activity in regards to;

1.1 Content knowledge of a group of Life Sciences teachers?

1.2 Instructional strategies applicable in relation to meiosis?

2. What are the benefits and challenges, (if any) of using a Japanese lesson study activity as a professional development activity at school level?

Answering the above-mentioned research questions, it is evident from the findings that the JLS approach applied simultaneously with the five TSPCK components satisfactorily. This improved the meiosis content knowledge including its teaching. In addition, the merging of the JLS approach with the components of the TSPCK in this study showed more benefits than challenges as depicted in the results.

The challenges encountered were viewed as windows of opportunities. For example, the continuous meetings over the holidays and weekends and the extension of the time allocated to allow all the participants to observe diligently of videotapes of the two meiosis lessons.

5.3. Research limitations

Different science researches have limitation. The following are the limitation for this study:

- The sample involved in my study is small and it originates from one area of the country. Therefore, the results of this study cannot be generalised.
- The sudden illness of the content expert who is the supervisor of this study impacted negatively on the data collection programme because two of the participants could not attend the initial post lesson discussions and one out of the two attended the second post lesson discussions. Their absenteeism was due to the fact that they were teaching grade twelves during the holidays at the time of data collection.
- The omission of observations by peers during the teaching of both research lessons may have provided more in depth data in relation to prior knowledge, representations and analogies, students behaviour including the conceptual teaching strategies.

5.4. **Reflections.**

The thought of bringing together these few teachers and form this community of inquiry, an endeavour that has not been done before in the local schools where the research happened. This showed that it is of critical importance to respect your colleagues, very essential to share any material or teaching strategies with your colleagues because when you need them as I did in the study it will not be a problem because bonds had already been established.

I realised that at the establishment of the community of inquiry it is challenging to those who do not know what a Lesson Study is. Therefore, the presence of the content expert is imperative throughout the phase of the JLS approach to correct errors and boost the morale

of the participants. However, once the JLS is established the role of the content expert will be minimalistic by being present and chairing the post lesson discussions.

I have realised that the JLS approach requires sacrifice in terms of time because teachers need to meet continuously after working hours. However, when the benefits of the JLS approach were communicated to the teachers that they formed a part of the community of inquiry as depicted by the teachers in this study.

The JLS approach needs money and workforce. I would not have been able to hire a videorecorder and offer catering because the phases of the JLS approach in this study were long. Therefore, I thank WITS for the equipment and the support to see this study through and I hope that their support will continue in order to allow more educators to form communities of inquiry.

Lastly, the joy I felt taking this study to my local school and the rewards of it, which I am still reaping because the community of inquiry for this study want us to continue with the JLS approach in the genetic topic.

5.5. The implications of the study.

It is evident from the study that teachers in this study had meiosis content knowledge gaps, meiosis misconceptions and erroneous ideas that emerge from the textbooks. The JLS approach afforded the participants in this study to bring forth those misconceptions through writing using PKS, verbalising during the workshops, which demonstrated that if it was not done I would not have been able to unearth the misunderstanding of meiosis concepts as shown in the results of the of the workshops. Furthermore, teaching of the two meiosis lessons demonstrated how teaching of meiosis happens in the reality of the classrooms. This JLS approach afforded all the participants an opportunity to gain instructional strategies and representations for their own use in their respective classrooms. The JLS is therefore an effective professional development activity that teachers can undertake at their respective schools. It will however require participation of content experts from local universities.

5.6. Implications for the teacher.

Teachers need to take the initiative to form communities of inquiry at school level to meet regularly in order to plan lessons including their enactment as depicted in this study. They shouldn't wait for the Education Department. For example, HOD's (Heads of the Departments) in their respective roles with their teachers can form a community of enquiry at school level and enlist the assistance of a content expert from a local university.

The teachers need to be aware that establishment of the communities of practice at first will be difficult and it will need them to meet after working hours. However, they need to be aware that their content knowledge will improve including their respective classroom practices especially when their professional development activities occur according to their

respective needs They will be in charge of their own progress through the guidance of the content knowledge expert as evident in my study. Once teachers become content experts, they will be able to make informed decisions in relation to textbooks that they use because they might have errors, simplistic explanations that promote misconceptions.

5.7. Implications for the Education Department.

This study implies that the Education Department needs to move away from professional development activities that are designed for the teachers' and embrace those that are modelled by the teachers according to. The Education Department needs to move away from professional development activities that take teachers away from school and apply those that involve all the stakeholders that happen within the school context.

Conclusion

Results from this study depicted that the meiosis content knowledge and its teaching improved through the JLS approach.

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Appendix A:

- CoRe.
- Data collection programme.
- List of expected meiosis concepts

Appendix B:

- Propositional knowledge statements.
- Initial meiosis lesson plan.
- Second meiosis lesson plan.
- Questionnaires.

Appendix C:

- WITS ethics clearance.
- GDE Research approval letter.