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The Use of Metacognitive Teaching Strategies in Chemistry: A Case Study of Upper Secondary School Teachers in Nyamagabe District, Rwanda

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***Abstract**: The study sought to investigate the use of metacognitive teaching strategies in chemistry subject by upper secondary school teachers in Nyamagabe district, Rwanda. The main purpose of this study was to investigate the way in which upper secondary chemistry teachers use metacognitive teaching strategies in their chemistry teaching. The study was guided by three specific objectives which were (i) to find out the way in which upper secondary school chemistry teachers use metacognitive teaching strategies in their chemistry teaching, (ii) to investigate issues that chemistry teachers face when using metacognitive teaching strategies in chemistry subject and to suggest measures to overcome the challenges that upper secondary teachers face when using metacognitive teaching strategies in their chemistry teaching. The theoretical framework of this study is built on Cognitive Developmental theory of Piaget (Piaget, 1973) and the Vygotsky's Social Constructivism theory of learning (1978). The pragmatic paradigm and case study research design were embraced. The target population composed of eleven secondary schools of Nyamagabe district with option bearing chemistry subject. The sample were composed of four upper secondary schools' chemistry teachers: G.S Kigeme A, E.S. Nyamagabe, E.S Sumba and G.S St Nicolas Cyanika as well as nine chemistry teachers that were selected through purposive techniques. Interview guide and adopted COPUS observation protocol were used to collect both qualitative data and quantitative data respectively. The obtained data was qualitatively and quantitatively analysed and the findings were presented and interpreted through the use of texts. The results from interviews and classroom observation revealed that most of chemistry teachers of Nyamagabe district use metacognitive teaching strategies to a given extent. The findings from this study showed that the lack of enough training for chemistry teachers, lack of enough instructional material and facilities, the lack of science educational software, overcrowded classroom and heavy chemistry teachers' workload are the main challenges faced by chemistry teachers for effective use of metacognitive teaching strategies in teaching chemistry. However, the study indicated that there are various alternative solutions to overcome the challenges that upper secondary chemistry teachers face when using metacognitive teaching strategies in their chemistry teaching. It is concluded that the effective use of metacognitive teaching strategies requires the availability of enough and regular training for chemistry teachers, standard classroom size, lowering chemistry teachers' workload, enough instructional materials and facilities. The study highlights that there is a needful effort for all activities, resources and facilities that are believed to lead the use of metacognitive teaching strategies in their chemistry teaching thus promoting quality of teaching chemistry subject in upper secondary schools. Based on the objectives coupled with the findings of the study, the study recommends that Rwanda Education Board should organize and provide regular technical trainings related to teaching chemistry subject in upper secondary school; put enough effort in availing enough instructional materials and facilities required for teaching chemistry subject and ensure that all the suggested measures to overcome the challenges faced by chemistry teachers in their chemistry teaching are addressed in order to promote effective use of metacognitive teaching to promote students' higher order thinking in chemistry learning.*

***Keyword:** Metacognitive teaching strategies, Chemistry teaching, Upper secondary school*

1. INTRODUCTION

The need of metacognitive teaching strategies for the purpose of enhancing academic performance has been emphasized in all over the world striving to provide quality of science education as the objective to promote critical thinking, creativity and innovation among new generation (Ku & Ho, 2010). The effective teaching and learning of chemistry is associated with the methodologies and strategies used by teacher during teaching and learning process. The metacognitive teaching strategies is one of teaching strategies which is believed to enhance effective teaching of chemistry in all topics to be taught in all levels of education (Cheung, 2015).

World science researchers explained that the pedagogical potential and possibilities of metacognition suggests "value-added" strategies or techniques in the sense that students might do something more than attempt to solve problems and engage in learning; they might also reflect not only on what but on how and why of what they have learned as a result of their experiences (Ellis, 2011; Ellis, Bond, & Denton, 2012; Krathwohl, 2002; Nuckles, Hubner, Dumer, & Renkl, 2010; Wilson & Smetana, 2011). Yet many researchers showed that students are not performing adequately particularly in the national examination as well as in classroom assessments of the chemistry subject (Salta &Tzougraki, 2004). On the other hand, in USA most of students fear to study sciences subjects saying that learning sciences such as chemistry, biology and physics require high order thinking as well as time consuming

(Sanstad, 2018). Again, science teachers often reflect on the content they are going to teach, but to what extend do chemistry teacher think reflectively about the pedagogy they use to teach specific chemistry skills? Consequently, in teaching successfully chemistry, teachers can use their metacognitive or high-level thinking about what, why and how they teach in order to manage and regulate their teaching so that it meets the needs of their students. In Germany, some empirical studies suggest that metacognitive strategy use is rare in comparison to traditional teaching approaches. For example, Kistner et al. (2010) found that German science teachers spent little time instructing their students how to learn effectively. Similarly, Leutwyler (2009) suggested that traditional curricula and instructional practices are insufficient for promoting metacognitive thinking. As a result, students tend not to use or refine their metacognitive strategies over time (Leutwyler, 2009). More often, the features necessary for fostering metacognitive learning seem to be absent during regular lessons, even though many of these features are associated with positive gains in achievement over time (Kistner et al., 2010). The critical features of the learning for fostering metacognitive strategy use is engaging curriculum (Leutwyler, 2009), assessment integration (Brookhart, 2001), consistent practice (Kistner et al., 2010), explicit strategy instruction (Kistner et al., 2010) and verbalizing (Scharlach, 2008).

Chemistry teachers in Sub-Saharan African countries endure to teach in unattractive way of lower order thinking regardless of the introduction of competence-based curriculum that require the use of think about their own thinking approach in their education system (UNESCO, 2004). Even though Brown (2003) has found that teachers hold constructivist beliefs about science problem solving, more importance is given to student's answers rather than problem solving solutions (Brosnan & Erickson, 1996) as cited in Mwelese (2014). The researcher who have been involved in SMASSE project have observed that in Kenya, students were not performing sufficiently the given experiments because students were not given a chance to do experiments themselves (The SMASSE Rwanda, 2009). Such practices persisted for a long time as Kenyan teachers were prefer using teacher friendly activities which concentrate on early syllabus coverage at the expense of the slow learners, the use of one particular textbook, moving ahead with faster learners at the expense of slow learners, giving too much assignments and not marking all of the students, and being biased in distribution of problems in class to only a few bright learners (Mwelese, 2014).

This problem of using metacognitive teaching strategies also has been in Rwandan schools (Rusanganwa, 2013). Metacognitive teaching strategies in Rwanda guaranteed to be at the fore front in improving quality of education for science subjects including chemistry. Since 2016, Rwanda Education system shifted from knowledge-based curriculum to competence-based curriculum (Ndihokubwayo, Habiyaremye, 2018). However, the researcher realized that chemistry study in secondary schools need an intervention of teaching strategies that would boost the students' achievement in chemistry subject (Tomory & Watson,2015). In spite of the various investigation of the use of metacognitive teaching strategies as synthesized in the existing literature, there is still deficit in the literature regarding the use of metacognitive teaching strategies in Rwandan Upper Secondary school.

The major focus of research in science education is the improvement of students' learning of science concepts (Treagust & Duit,2008). Alongside this focus is increased attention to developing students' learning processes and their metacognition as an integral priority (Thomas,2012). Further, as will be explained, it is essential to acknowledge the role of metacognition in students' chemistry achievement. The position taken in this research topic is that the development and enhancement of students' metacognition should be a high priority for chemistry teachers to upgrade students' academic performance in chemistry subject for upper secondary school.

Therefore, the use of metacognitive teaching strategies should involve teachers themselves in improving chemistry teaching, thus quality of education. The researcher is interested in the use of metacognitive teaching strategies in teaching chemistry subject within secondary schools of Rwanda since none of the studies focused on the investigation into the use of metacognitive teaching strategies towards chemistry subject in upper secondary schools of Rwanda. Within this context, it became necessary to analyze the use of metacognitive teaching strategies in chemistry subject by upper secondary chemistry teachers within schools in Nyamagabe district.

The study was guided by following specific objectives:

1. To find out the way in which upper secondary school chemistry teachers use metacognitive teaching strategies in their chemistry teaching.
2. To investigate issues that chemistry teachers face towards the use of metacognitive teaching strategies in chemistry subject in upper secondary schools.
3. To suggest measures to overcome the challenges that upper secondary teachers face when applying metacognitive teaching strategies in their chemistry teaching.

2. Literature Review

2.1. Metacognitive Teaching Strategies

Teachers need to trace metacognitive strategies in learning so that novices are more careful in determining problem solving strategies and obtain expected learning outcomes (Aliyah, Erman, & Sugiarto, 2018). The teacher supports the learners to use metacognitive skills and strategies such as tasks analysis, planning, monitoring, checking and reflection, self and group monitoring skills, reading skills and writing skills, self-regulation skills, self-assessment and group discussion as well as think about their own thinking that help them in science problem solving (Mevarech & Kramarski, 2003; Veenman, 2006; Brunstein & Glaser, 2011; Fidalgo, Torrance, & Garcia, 2008; Tracy et al., 2009).

In this neck of the woods, the philosophy of metacognitive teaching strategies is relatively new paradigm in improving students' academic performance that emerged in the early 1979's which is called a shift from traditional paradigm of teaching to transformative teaching and learning strategies. Monitoring strategies identified in the analysis were repeatedly reading material until one can understand, using rules such as molecular structure, molecular formula, mathematical formula, equation, diagram and graph; identifying errors such as writing, drawing, molecular formula, molecular structure, equation, observation of changes, monitoring carefully in problem solving; modelling, diagramming, answer checking, and practicing (Boulaware-Gooden, Carreker, Thornhill, & Joshi, 2007; Huff & Nietfeld, 2009; Reynolds & Perin, 2009, Ellis & Bond,2014).

Metacognitive strategies for evaluating thinking included reflecting on the concept and objective achieved as well as reflecting on efficient strategies comprising modelling, independent practice, self-testing, and answer checking (Ramdass & Zimmerman, 2008; Zirkle & Ellis, 2010). Modelling involves showing students specific procedures to follow for using a strategy, the others additional strategy for teaching includes mnemonics, answer checking, checklist and goals attainment (Ellis & Bond,2014).

Encouraging the students to ask questions themselves in a chemistry subject is one of the metacognitive strategies that can be used for emerging metacognition within the framework of constructivism learning. Teacher should ask the following questions as metacognitive strategy instruction in activating the thinking and contributing to the development of metacognitive abilities as: What about next? What do you think? Why do you think so? And how can you prove this? Most importantly, these effective questions are a type of skeletons that can construct a good self- questioning habit as a common metacognitive intellectual capacity monitoring strategy (Hacker & Dunlosky, 2003).

Metacognition is a multidimensional construct, which is related to important concepts such as motivation (Zimmerman, 1995; Borkowski, Chan & Muthukrishna, 2000), critical thinking (Kuhn, 1999), problem-solving (Flavell, 1976), learning strategies (Čáp & Mareš, 2001), or self-regulated learning (Boekaerts, 1997; Zimmeman, 2002).

The effective teaching of chemistry is not only confined to the school leadership, the availability of instructional materials and facilities but also focused on the methodologies and strategies used during teaching and learning process (Schwartz, 2006). Various researchers highlight some common strategies used in everyday teaching to foster the learning and internalization of metacognitive strategies that comprising explicit teaching (Souvignier & Mokhlesgerami, 2006), supporting students to plan, monitor and evaluate their learning (Schraw & Gutierrez,2015), developing rubrics (Zemira, & Bracha,2014), modelling thinking (Kollar, Fischer & Hesse, 2006) and questioning (Black, McCormick, James, & Pedder, 2006).

1.2. Advantages of Metacognitive Teaching Strategies

It has become increasingly evident that metacognition is a key to the multiple agendas that characterize science education today (Thomas, 2012). The use of metacognitive teaching strategies enables teachers to facilitate learners in learning chemistry subjects. The metacognitive teaching strategies qualify learners' scientific literacy and their understanding of the scientific inquiry; learners undertake particular procedure of both physical and cognitive; learners monitor their progress toward the learning outcomes, learners evaluate their learning progress; learners reflect on the outcomes of their inquiry; improving practices and continuously monitor new information that is presented to them (Wilson& Conyers,2016).

Additionally, metacognitive teaching strategies embrace thinking aloud when solving problems individual or in groups, monitoring their comprehension when solving problems in group discussion, developing reflective habits when solving problems, using the internet to search for information for their assignment, think about their own thinking, always providing solutions to problems themselves in the first place and later showing the results to other people to check the steps or procedure as well as the answers to see whether they were correct or wrong and proven the good steps to get correct answer when the answer was wrong (Tachie, 2019).Consequently, the use of metacognitive teaching strategies such as planning, reflection and self-monitoring of problem-solving steps help learners greatly to understand and apply many chemistry concepts which they did not know before.

For example in mathematics study, metacognitive teaching strategies enable learners to solve mathematics problem in which learners are going to the chalk-board to do additions and subtraction of integers using illustrations and learning aids; learners forming groups to discuss how to solve the problem among themselves, including the procedure to solve the problem and with some of the quicker learners assisting slower learners and learners challenging others on the procedures used to solve the problem at hand spontaneously (Boileau,2012).

The findings from the learners 'direct responses concerning monitoring and evaluation strategies used in problem-solving revealed that learners actually did use monitoring and self-assessment strategies to monitor their comprehension of a problem (Stillman & Galbraith, 1998). The study of metacognitive in the field of science education create mature students and have a meaningful impact on students' learning and teachers' pedagogies so that improvement in students learning is upgraded (Schulz, & FitzPatrick, 2016).

The practice of metacognitive teaching strategies boosts the effective teaching of chemistry subjects thus promoting students' academic performance. Metacognitive teaching strategies are vital to maximize scientific and technological innovation which ultimately enriches the standard of living and reduces poverty in societies (Essuman, 2017). Performing various tasks at a particular time entails different mental operations coupled with developmental stages; this leads to the effective application of metacognitive skills and strategies through thinking about one's own thinking in order to affect the outcome of any intellectual undertaking (Whitebread et al., 2009). Consequently, assisting the learners to acquire metacognitive skills and strategies, teacher must embrace the practice of metacognitive teaching strategies during their assistance process.

Metacognition teaching strategies enhances learners' skills and further promotes teachers' content knowledge through thinking about their own thinking in learning (Posthuma,2011; Fischer, 1998). Dawson (2008) states that "metacognitive strategies are usually conceptualized as an interrelated set of competencies for learning and thinking and comprise many of the skills required for active learning, critical thinking, reflective judgment, problem-solving, and decision making". In other words, learners who have well-developed meta-cognitive skills through thinking about their own thinking are better problem solvers, decision makers and critical thinkers, all of which improve their learning skills (McGuinness,2005).

Metacognition is therefore an important aspect of student learning, since the development of metacognitive skills and strategies gives students the ability to better organize their thought processes and to refine their thinking skills in problem-solving (Joseph 2010; Knox, 2017; Schraw & Graham, 1997). Livingston (1997) maintains that basic cognitive knowledge is required to achieve a particular goal since it guides an individual to achieve a goal in a learning situation. Furthermore, the appropriate use of metacognitive skills/strategies are beneficial for individuals to gain knowledge, skills and attitudes as well as the intellectual abilities that guide and direct intellectual processes in learning (Gok 2010; Knox, 2017; Lai 2011).

Teacher should create a communicating environment for students' effective interaction encouraging them to verify in constructing knowledge through various process and generating new knowledge through self-exploration and learners need to be aware that they must be an active learner who take initiatives and responsibilities in their learning (Ghasempour, Bakar& Jahanshahloo, 2013). Chick and Kernahan (2009) pointed out that metacognitive strategies empower students to think about their own thinking. Awareness of the learning process enhances control over their own learning. It also enhances personal capacity for self-regulation and managing one's own motivation for learning (Hadwin, Järvelä, & Miller, 2011). Explicit attention to and application of thinking skills enables students to develop an increasingly sophisticated understanding of the processes they can employ whenever they encounter both the familiar and unfamiliar, to break ineffective habits and build on successful ones, building a capacity to manage their thinking (Myhill, Jones, & Hopper,2005).

1.3. Issues of applying metacognitive teaching strategies

The ability to think adaptively and reason about complex problems requires weighing issues and arguments and considering alternative points of views (Dole & Sinatra, 1998). The capability to reason and think critically must be fostered for most students to engage with information in a critical fashion. Various issues related to the applicability of metacognitive teaching strategies has been assessed by educational researchers and teachers. For instance, Lai (2011) stressed that assessment of metacognition is challenging for the fact that metacognition is a complex construct that involves a number of different types of knowledge and skills. The author added that metacognition is not directly observable and it may be confused in practice with both verbal ability and working memory capacity. Basing on the ambiguity of the definition and theory of metacognition, metacognition is usually assessed in two principal ways: observations of students' performance or by self-report inventories (Greene,2015). Therefore, few popular techniques used in measuring metacognitive knowledge and processes are: self-report such as questionnaires or rating scales, error detection, interview (structured, semi structured, unstructured, open-ended, closed, introspective, and retrospective) and thinking-aloud.

The deficit or one size-fits-all models of metacognition should be treated with some caution because it could be potentially dangerous, if not unreasonable, to assume that we will ever be able to construct a model of the ideal metacognitive student. This is because what is valued as effective thinking and thinking processes, and as appropriate metacognition, can vary across cultures as was noted by Thomas (2006). Despite this forewarning, it is known that metacognition is malleable to classroom interventions that are carefully implemented and that changing classroom environments to become more metacognitive oriented is a key to developing and enhancing students' metacognition. However, all efforts to develop and enhance students' metacognition take place within sociocultural contexts whose influence cannot be understated.

On the other hand, White (1998) noted that since metacognition is a mental activity, its presence can be inferred, but not observed directly. However, the extent to which science teachers are themselves metacognitive is not altogether clear. Zohar (1999; 2004) highlighted the importance of teachers' metacognitive knowledge and the

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difficulty that teachers have in changing from traditional instruction to that which focuses on the teaching of higher-order thinking. She also noted the difficulty that teachers have in articulating their thinking patterns during problem solving and concluded that adequate and appropriate teacher metacognitive declarative knowledge is essential for the teaching of higher-order thinking. In the same line, Leou et al. (2006) found that teachers have challenges regarding their own metacognitive knowledge in relation to higher-order thinking processes is important in facilitating transfer of that knowledge into their own pedagogical practices. More research on teacher metacognition might enable increased effectiveness of professional development activities that aim to help teachers to develop higher-order thinking and metacognition in science learning environments.

Further, as noted by Georghiades (2004), 'the notion of metacognition is largely unknown to the average science teacher'. This presents a highly problematic situation if students' metacognition is to receive increased attention that it deserves. Georghiades added that even those who are familiar with the concept of metacognition lack the resources or authority to facilitate metacognition in their teaching. It could reasonably be argued that time is the only resource that might not easily be available to teachers who adopt this second approach. It could also be argued that teacher education programmes should graduate science teachers who possess the characteristics identified above.

2. Methodology

This study adopted pragmatic paradigm approach. Pragmatism offers an experience-based, action-oriented framework whereby the purpose of research is to help us address the issues of dealing with how we experience and come to know the world in a practical sense (Hothersall 2019). The study used case study as a research design (Tetnowski,2015). The case study is an effective way of doing research while dealing with problems involving human interaction, it does not need a large sample, aims for describing a phenomenon, analytic generalization or generate a theory though the use of multiple methods of data collection, data analysis and triangulates data (Teegavarapu et. al, 2008). This study employed both qualitative and quantitative methods to best understand a research problem. The inductive logical approach used by the research by gathering detailed information from participants and then form information into categories and themes (Creswell, 2009).

Quantitative research has been used due to the use of COPUS observation protocol while qualitative research has chosen because the sample size was very small and was purposefully selected from the individuals who have the most experience with the study phenomena from whom the research collect data in form of word or texts about the central phenomena (Platton, 2002). The main types of qualitative data that could be collected in relation to the objectives of this research was interview guide (Ivankova et al, 2007).

Through this study, upper secondary school chemistry teachers of Nyamagabe district were targeted by this study because they are keen to have all the desired skills and knowledge and possess enough information related to the use of metacognitive teaching strategies in chemistry subject. In addition, chemistry teachers were targeted because they are the direct planners during teaching and learning of chemistry subject. Chemistry teachers were therefore in good position to provide information on the strategies adopted to enhance the quality of educational output in their district while teaching chemistry subject. In schools hosting both upper and lower secondary levels, the teachers who taught in both levels, they would also be part of the concerned population in this study. Nyamagabe district have ten secondary school hosting option having chemistry as subject. Those schools are E.S Mushubi, G.S Bitandara, G.S Gatare, G.S Kiraro, E.S Sumba, G.S Kigeme A, G.S Kigeme B,E.S Kaduha ,E.S Nyamagabe and G.S st Nicolas Cyanika. The target population of chemistry teachers in secondary school of Nyamagabe were 20 chemistry teachers. As the present study is designed as mixed method research, the selection of participants included purposive qualitative approach for chemistry teachers and classroom observation through the use of COPUS observation protocol that generate quantitative data. To get the sample for this study, first the schools were stratified according to their categories: Twelve years' basic education (12YBE) versus boarding secondary schools. Stratification of the school helped to ensure that all the categories of schools are represented. Furthermore, upper secondary schools' chemistry teachers of the selected schools were purposively included in the sample for this study. The sample was composed by E.S Nyamagabe, G.S Kigeme B, E.S Sumba and G.S St Nicolas Cyanika and nine chemistry teachers who taught chemistry subject in upper secondary schools from aforementioned secondary schools. The research instruments for this study were interview schedule and classroom observation protocol. Detailed guided open questionnaires of interview guide on investigation of metacognitive teaching strategies were used to collect data from upper secondary schools' chemistry teachers. To avoid any possible loss of information and to ensure accurate responses, personal administration, the researcher administered the semi-structured interview guide to chemistry teachers. Using a recorder, the researcher recorded the interview. The Classroom Observation Protocol for Undergraduate STEM, (COPUS) was also used to collect quantitative data. All interviews took place at schools in place and at time agreed upon between upper secondary school chemistry teachers and researcher as per academic timetable. Participants were with all prospect to discuss in an open-ended way whatever they desired in relation to the topic being investigated. Through they provided permission, the research recorded and wrote all the responses given by the participants, it is acknowledged that for interview to be successfully, a number of measures have taken into consideration. As suggested by Fraenkel and Wallen (2007), the interview process followed the measures such as respect the individual being interviewed, being natural as possible to avoid deception in any form, ask the same questions in different forms when it appear necessary, to ask interview to repeat the answer when it appear necessary and avoiding reading questions during the interview schedule. To supplement the data gathered from interview, a number of observation were conducted and three classroom observations were done for each chemistry interviewed as recommended by COPUS observation protocol. Thus, the adopted COPUS observation protocol was used to record all activities done by both teachers and learners during chemistry teaching for a lesson of 40 minute. Three lessons were observed for each chemistry teacher while teaching the lesson of chemistry in upper secondary school chemistry teaching. About 27 lessons were observed during chemistry teaching for upper secondary schools in Nyamagabe district.

Through this study, the classroom observation protocol for Undergraduate STEM (COPUS) that was developed by Smith et al, it has been adopted during classroom observation process (Smith et al, 2013). COPUS is a valid and reliable tools for gathering data related to what is happening during classroom lesson delivery (Van Tassel-Baska, Quek, & Feng,2006).It has 28 codes among them 13 describe teacher's activities, 12 describe learners' activities during lesson delivery while 3 codes describe how the teacher engage his/her students. The COPUS developers advise researchers to observe at least three lessons for each teachers teaching one subject to the same students in order to enhances reliability and the validity of teachers and learners' practices. We used the COPUS to observe lessons of nine different chemistry teachers in upper secondary schools making up 27 observed lessons. The duration of each lesson was 40 min in secondary schools of Rwanda. COPUS was proven to be valid and reliable during classroom observation (Smith et al,2013) and was used in the context of Rwanda secondary school (Ndihokubwayo et al., 2020b). For each class, we observed the lesson of chemistry for three times. In the view of Sidhu's (2003), observation as a research tool must always be expert, directed by specific purpose systematic, carefully focused and thoroughly recorded and also like other search procedures. Observation must be subjected to accuracy, validity and reliability. Data were collected by the researcher himself to maximize the validity and reliability of data collected. Teacher activities codes were Lec-Lecturing; RtW-Realtime Writing; FUp-Follow-up questions; PQ-Posing non-clicker question, CQ-Posing Clicker question, AnQ-Answer questions, MG-Moving in the classroom and Guiding students; 1o1-One-on-one teacher support; D/V-teacher making demonstration by experimenting, simulation, etc, Adm-Administrating or giving feedback on tests; and W-Waiting during organizing materials of fixing tools such as a projector. The students' codes were L-Listening, AnQ-Answering teacher's questions, SQ-Asking question, WC-Whole-Class discussion, SP-Presentation of findings, In-Individual thinking, CG-Group work with Clickers, WG-Group working using worksheets, OG-Other Group, Prd-Prediction, T/Q-Test/Quiz, W-Waiting, and O-Other (Smith et al., 2013).

The obtained raw data have been coded and edited into form that is suitable for analysis. Thematic analysis approach has used to analyze the collected qualitative data from interview questions. This means that responses given by upper secondary schools' chemistry teachers for the open-ended questions of interview were put into relevant themes. After the analysis of data textual mode has used to present qualitative findings. The analysis of text, representation of information in figures and tables and personal interpretation of the findings all inform in qualitative procedure was conducted. Editing data consist of pinpointing and eradicating errors made by respondents in preparation for investigation. After editing, the next step was coding which consist of transforming raw data into a computer readable format suitable for analysis. Before the analysis began, the researcher organized, transcribed and saved and the researcher assessed them to understand them. In qualitative data "coding is a process of reading carefully through the transcribed data, line by line, and dividing it into meaningful analytical units" (Nieuwenhuis, 2007). The coding of data enhances the researcher to retrieve and collect together all the text and other that they have associated some thematic ideas. Once the transcribed data were coded, the data was organized and combined into themes or categories. After all the aforementioned steps, the data was structured and interpreted to investigate the use of metacognitive teaching strategies in chemistry teaching. The interpretation of analyzed data would then search for emerging patterns, association, concepts and explanation of data. On the other hand, the analysis of data from classroom observation, the data were analyzed through the use of the COPUS visualization template in Excel sheet format found at https://tep.uoregon.edu/files/copus_with_visualization.xlsx.
The template has three sheets such as COPUS data entry, percent activity graph and percent interval graph. From the field, the researcher used the COPUS data entry sheet. The sheet contains automatic formulas that analyzed the data entered directly by counting the number of times code observed and by counting the number of 2-min any segments any code appeared. The provided template could be entered in a lesson up to 110 min, however, we were obliged to extended the formula to accommodate all data of three consecutive lesson for each chemistry teacher. During the analysis each code was assumed up to provide the number of times that code was checked where the right side of the table of data (column AE) shows any code that was checked across a 2-min interval. When one or many codes was checked, "1" score was marked, while a 2-min interval that none of the code was checked, then a "0" score was marked. Thus the sum in this column was located AE2191 and shows the number of time intervals (Smith et al ,2013). Since it was difficult to analyse each code for fostering lesson observation such as students' engagement, active learning or lecturer based class, or passive learning, (Smith et al,2013) has proposed to collapse the code into small groups. These groups are eight in total, the four

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collapse code for teachers are presenting (P), guiding (G), administration (A) and others (O) as well as four collapse code for learners are receiving,(R), Talking to class (STC), Working (SW) and others (SO) (Smith et al,2013). In this study, the COPUS data were analyzed through the assessing the percentage of activities done by both teachers and learners during teaching and learning process for time interval of two minutes. Finally, the percent of activities graphs displayed these data and showed the computed percentage of each code.

3. Findings and discussions

This research study was to investigate the way in which Nyamagabe district upper secondary chemistry teachers use metacognitive teaching strategies in their chemistry teaching. The purpose of this study was to operationalize the research objectives, specifically on responding to the research questions in light of analysis of the data: (a) In which ways upper secondary school chemistry teachers use metacognitive teaching strategies in their chemistry teaching?;(b) What are the issues that upper secondary schools' chemistry teachers face while applying metacognitive teaching strategies?; and (c) What are the measures that can be applied to overcome the challenges that upper secondary chemistry teachers face while applying metacognitive teaching strategies in their chemistry teaching? Collection of data took place, qualitative investigation was designed and conducted. Methods of investigation that include of data collection techniques and the design of research was embraced. The investigation of use of metacognitive teaching strategies in their chemistry teaching, the challenges faced by chemistry teachers during the implementation of metacognitive teaching strategies and some suggested alternative solutions required for effective use of metacognitive teaching strategies has been valuated through the analysis of interview respondents and classroom observation through the use of COPUS Observation protocol.

The first objectives of this study aimed at to find out the way in which Nyamagabe district upper secondary school chemistry teachers use metacognitive teaching strategies in their chemistry teaching. The findings showed that 8 out 9 of upper secndary schools teachers agreed that they did planning for chemistry teaching strategies in their chemistry teaching, 6 out of 9 of upper secondary school teachers agreed that they did monitoring strategies of the learners' work, 5 out of 9 of upper secondary chemistry teachers in Nyamagabe district said that they used evaluating strategies in their chemistry teaching. The classrooom observation through the use of COPUS observation protocol revealed that 35 % learner's activities was learners' work and learner's talking to class respectivily whereas as 30 % of learners' activities was receiving the knowledge during learning the chemisrty lesson. The classroom observation through the use of COPUS observation protocol showed that 51% of teachers' activities was guiding the learners to learn, 37% of teachers' activities was to present the lesson to the learners, 8% of teachers' activities were administration activities whereas 4% of teachers' activities was others activities that were done by the chemistry teachers in order to facilitate learners' to learn chemistry lessons. Through the analysis of findings of teaching strategies of chemistry teaching, the results of interview indicated that most of upper secondary chemistry teachers plan in their chemistry teaching. The planning for teaching chemistry subject were associated with the assessment of the levels of students understanding as well as for making research and chemistry problem solving. The results is in line with the findings of Brunstein and Glaser (2011); Fidalgo, Torrance and Garcia (2008) and Tracy et al.(2009) who found that planning strategies included activity of thinking, reading and writing of what ones know and do not know, identifying the place to find information that had not known yet; modelling; activity determining goals attainment; select appropriate strategies; activating the relevant resources; determining the intermediate results; allocate resources; checklists and plan representations to support understanding of the problem such as diagrams, graphic organizers and mnemonics.

In the same manner, the findings planning for teaching chemistry that used by the upper chemistry teachers were in line with the findings of Mevarech and Kramarski (2000) and Veenman (2006) who found that the teacher supports the learners to use metacognitive skills and strategies such as tasks analysis, planning, monitoring, checking and reflection, self and group monitoring skills, reading skills and writing skills, self-regulation skills, self-assessment and group discussion as well as think about their own thinking that help them in science problem solving. Likewise, the results are in line with the findings of Thomas (2012) who found that the development of students' metacognition requires that they undertake conscious reflection on the efficacy of the learning process, cognitive process and using means of assisting such as concept maps, reading charts, ven diagrams, theory-evidence coordination rubrics and inquiry flowcharts which improve and represent students' understandings of science.

Similarly, the results is in line with the findings of Boulaware-Gooden, Carreker, Thornhill, and Joshi (2007); Huff and Nietfeld (2009) ; Reynolds and Perin (2009) and Ellis and Bond (2014) who found that monitoring strategies identified in the analysis were repeatedly reading material until one can understand; using rules such as molecular structure, molecular formula, mathematical formula, equation, diagram and graph; identifying errors such as writing, drawing, molecular formula, molecular structure, equation, mathematical formula and observation of changes; monitoring carefully in problem solving; modelling, diagramming, answer checking, and practicing.

Likewise, the results are in line with the findings of Ramdass and Zimmerman (2008) and, Zirkle and Ellis (2010) who found that metacognitive strategies for evaluating thinking included reflecting on the concept and objective achieved as well as reflecting on efficient strategies comprising modelling, independent practice, self-testing, and answer checking.

Equally important, the results is in line with the findings of Wilson and Conyers (2016) who found that the metacognitive teaching strategies qualify learners' scientific literacy and their understanding of the scientific inquiry; learners undertake particular procedure of both physical and cognitive; learners monitor their progress toward the learning outcomes, learners evaluate their learning progress; learners reflect on the outcomes of their inquiry; improving practices and continuously monitor new information that is presented to them. Likewise, the findings are in line with Whitebread et al. (2009) who found that performing various tasks at a particular time entails different mental operations coupled with developmental stages that leads to the effective application of metacognitive skills and strategies through thinking about one's own thinking in order to affect the outcome of any intellectual undertaking. Additionally, the results are in line with the findings of Gok (2010); Knox (2017) and Lai (2011) who found that the appropriate use of metacognitive skills/strategies benefits individuals to gain knowledge, skills and attitudes as well as the intellectual abilities that guide and direct intellectual processes in learning. But also the results are in line with the findings of Anderson and Krathwohl (2001) who identified that metacognitive teaching strategies facilitate teacher to engage learners in higher order level of the hierarchical nature of knowledge including analyzing, evaluating and creating that encourage higher order thinking among learners.
Therefore based on the findings of interview guide and classroom observation, it is clear that the upper secondary school use metacognitive teaching strategies in their chemistry teaching at certain extent in Nyamagabe district.

The second objectives of this study aimed at to investigate issues that chemistry teachers faced towards the use of metacognitive teaching strategies in chemistry subject in Nyamagabe district upper secondary schools. The results identified that various issues faced by chemistry teachers were related to planning strategies for chemistry teaching, monitoring strategies for chemistry teaching and evaluating strategies for chemistry teaching. The results revealed that there are many challenges for upper secondary schools 'chemistry teachers that inhibit them for effective implementation of metacognitive teaching strategies in their chemistry teaching. Those challenges included the lack of enough and regular technical trainings related to chemistry teaching, enough training on use of metacognitive teaching strategies, overcrowded classroom, lack of enough instructional materials and resources, resistance to change for some chemistry teachers, lack of enough educational software, overwork load for chemistry teachers and time constraint. The results were in line with the findings of Georghiades (2004) who found that the use of metacognitive teaching strategies lack the resources or authority to facilitate metacognition in their teaching. The findings are in line with the findings of Georghiades (2004) who reasonably argued that the time is the only resource that might not easily be available to teachers while adopting the use of metacognitive teaching strategies. During the classroom observation, it was noticed that the upper secondary chemistry teachers faced with many challenges that inhibit them to use metacognitive teaching strategies in their chemistry teaching. it was observed that the teachers miss enough instructional materials and facilities, they had heavy workload, the classroom was overcrowded and the resistance to change for some chemistry teachers who continued to use traditional method of chemistry teaching.

The third objectives of this study intended to determine measures to overcome the challenges that Nyamagabe district upper secondary teachers faced when using metacognitive teaching strategies in their chemistry teaching. The study indicated that there were various alternative solution to overcome challenges faced by chemistry teachers in use of metacognitive teaching strategies in their chemistry teaching in Nyamagabe district. Those alternative solutions include the provision of regular training on chemistry teachers, reduce the classroom size, reduce chemistry teachers' workload, avail enough instructional materials, facilities and resources, use of education software related to the teaching of some chemistry topic through virtual laboratory practice and training related to the use of metacognitive teaching strategies in their chemistry teaching.

5. Conclusion and recommendation

The conclusion has been made as per the objectives of the study. Based on the findings of the study of the first objective, the study concluded that the upper secondary schools' chemistry teachers in Nyamagabe district use metacognitive teaching strategies in their chemistry teaching at a certain extent.

As the second objectives aimed at find out the challenges faced by chemistry teachers in their chemistry teachers, based on the findings of the study, it concluded that the lack of enough and regular training for chemistry teachers, lack of enough instructional material, facilities and resources, the none use of educational software through virtual laboratory experiment, overcrowded classroom and heavy chemistry teachers workload are the main challenges faced by chemistry teachers for effective use of metacognitive teaching strategies in their chemistry teaching.

The third objectives of the study was to suggest measures to overcome the challenges that Nyamagabe district upper secondary teachers faced when using metacognitive teaching strategies in their chemistry teaching and it is concluded that the effective use of metacognitive teaching strategies require the availing enough and regular training for chemistry teachers, reduced students 'classroom size, reduced chemistry teachers workload, avail enough instructional materials, facilities and resources, avail enough education software for virtual laboratory experiment practices among others alternative solutions that were provided by the chemistry teachers in Nyamagabe district. Based on the objectives coupled with the findings of the study, the following recommendations have been provided.

1) The Rwanda Education Board should organize and provide regular training related to the use of metacognitive teaching strategies in teaching chemistry subject in upper secondary school.

2) The Rwanda education Board should put enough effort in availing enough instructional materials, facilities, resources and educational software required for teaching chemistry subject.

3) The Rwanda education board should ensure that all suggested measures to overcome the challenges face by chemistry teachers in their chemistry teaching are addressed.

REFERENCES

Aliyah, H., Erman, E., & Sugiarto, B. (2018, July). Students' Metacognitive Thinking Process in Solving Covalent Bonding Problem Based on Academic Ability Level. In *Mathematics, Informatics, Science, and Education International Conference (MISEIC 2018)*. Atlantis Press.

Black, P., McCormick, R., James, M., & Pedder, D. (2006). Learning how to learn and assessment for learning: A theoretical inquiry. *Research Papers in Education*, *21*(02), 119-132.

Boekaerts, M. (1997). Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students. *Learning and instruction*, *7*(2), 161-186.

Boileau, N. (2012). *Two Secondary School Mathematics Teachers' Use of Technology through the Lens of Instrumentation Theory* (Doctoral dissertation, Concordia University).

Cheung, D. (2015). The combined effects of classroom teaching and learning strategy use on students' chemistry self-efficacy. *Research in Science Education*, *45(1), 101-116.*

Chick, N., Karis, T., & Kernahan, C. (2009). Learning from their own learning: How metacognitive and meta-affective reflections enhance learning in race-related courses. *International Journal for the Scholarship of Teaching and Learning*, *3*(1), n1.

Creswell, J. W. (2009). *Research design: Qualitative, Quantitative and Mixed Methods Approaches* (3rded.). London: Sage.

Ellis, A. K., Denton, D. W., & Bond, J. B. (2014). An analysis of research on metacognitive teaching strategies. *Procedia-Social and Behavioral Sciences*, *116*(21), 4015-4024.

Essuman, B. (2017). *The use of creative arts to teach challenging topics in english language, mathematics and natural science at* (Doctoral dissertation, School of Graduate Studies, Kwame Nkrumah University of Science and Technology).

Fraenkel, J. R., & Wallen, N. E. (2007). *How to design and evaluate research in education,*

(6thed.). New York: McGrawHill.

Ghasempour, Z., Bakar, N., & Jahanshahloo, G. R. (2013). Innovation in teaching and learning through problem posing tasks and metacognitive strategies. *International journal of pedagogical innovations*, *1*(01).

Greene, B. A., Miller, R. B., Crowson, H. M., Duke, B. L., & Akey, K. L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary educational psychology*, *29*(4), 462-482.

Greeno, J. G. (1989). Situations, mental models, and generative knowledge. *Complex information processing: The impact of Herbert A. Simon*, 285-318.

Hadwin, A. F., Järvelä, S., & Miller, M. (2011). Self-regulated, co-regulated, and socially shared regulation of learning. *Handbook of self-regulation of learning and performance*, *30*, 65-84.

Ivankova, N. V., Creswell, J. W., & Plano Clark, V. L. (2007). Foundations and approaches to mixed methods research. In K. Maree (Ed.). *First steps in research*, (pp. 253- 280). Pretoria: Van Schaik.

Jack, G. U. (2013). Concept mapping and guided inquiry as effective techniques for teaching difficult concepts in chemistry: effect on students' academic achievement. *Journal of Education and practice*, *4*(5), 9-15.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of higher education*, *6*(5), 26-41.

Kollar, I., Fischer, F., & Hesse, F. W. (2006). Collaboration scripts–a conceptual analysis. *Educational Psychology Review*, *18*(2), 159-185.

Ku, K. Y., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and learning*, *5*(3), 251-267.

Langdon, J., Botnaru, D. T., Wittenberg, M., Riggs, A. J., Mutchler, J., Syno, M., & Caciula, M. C. (2019). Examining the effects of different teaching strategies on metacognition and academic performance. *Advances in Physiology Education*, *43*(3), 414-422.

McGuinness, C. (2005). Teaching thinking: Theory and practice. In *BJEP monograph series II, number 3-pedagogy-teaching for learning* (Vol. 107, No. 126, pp. 107-126). British Psychological Society.

McGuire, S. Y. (2015). *Teach students how to learn: Strategies you can incorporate into any course to improve student metacognition, study skills, and motivation*. Stylus Publishing, LLC.

Myhill, D., Jones, S., & Hopper, R. (2005). *Talking, listening, learning: Effective talk in the primary classroom*. McGraw-Hill Education (UK).

Ndihokubwayo, K., & Habiyaremye, H. T. (2018). Why did Rwanda shift from knowledge to competence based curriculum? Syllabuses and textbooks point of view. *African Research Review*, *12*(3), 38-48.

Nieuwenhuis, J. (2007). Qualitative research designs and data gathering. In K. Maree (Ed.). *First steps in research*, (pp. 69-97). Pretoria: Van Schaik.

Nilsson, P. (2014). When teaching makes a difference: Developing science teachers' pedagogical content knowledge through learning study. *International Journal of Science Education, 36(11), 1794-1814.*

Nja, C. O., Cornelius-Ukpepi, B., Edoho, E. A., & Neji, H. A. (2020). Enhancing Students' Academic Performance in Chemistry by Using Kitchen Resources in Ikom, Calabar. *Educational Research and Reviews*, *15*(1), 19-26.

Ojose, B. (2008). Applying Piaget's theory of cognitive development to mathematics instruction. *The mathematics educator*, *18* (1).

O'Cathain, A., & Thomas, K. J. (2004). " Any other comments?" Open questions on questionnaires–a bane or a bonus to research?*BMC medical research methodology*, *4*(1), 1-7.

Papleontiou-Louca, E. (2003). The concept and instruction of metacognition. *Teacher development*, *7*(1), 9-30.

Platton, M. Q. (2002). *Qualitative research and evaluation methods*, (3rded.). Thousand Oaks: Sage.

Ram, P. (1999). Problem-based learning in undergraduate instruction. A sophomore chemistry laboratory. *Journal of Chemical education*, *76*(8), 1122.

Rusanganwa, J. (2013). Multimedia as a means to enhance teaching technical vocabulary to physics undergraduates in Rwanda. *English for Specific Purposes*, *32*(1), 36-44.

Salta, K., & Tzougraki, C. (2004). Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education*, *88*(4), 535-547.

Sanstad, E. A. (2018). The Fear of Science: a Study of Science Anxiety and the Learning Capabilities of Adult College Students.

Schraw, G., & Gutierrez, A. P. (2015). Metacognitive strategy instruction that highlights the role of monitoring and control processes. In *Metacognition: Fundaments, applications, and trends* (pp. 3-16). Springer, Cham.

Schulz, H. W., & FitzPatrick, B. (2016). Teachers' understandings of critical and higher order thinking and what this means for their teaching and assessments. *Alberta Journal of Educational Research*, *62*(1), 61-86.

Schwartz, A. T. (2006). Contextualized chemistry education: The American experience. *International Journal of Science Education*, *28*(9), 977-998.

Shamsudin, N. M., Abdullah, N., & Yaamat, N. (2013). Strategies of teaching science using an inquiry based science education (IBSE) by novice chemistry teachers. *Procedia-Social and Behavioral Sciences*, *90*, 583-592.

Smith, MK, & Jones, F. HM, Gilbert, SL, & Wieman, CE (2013). The classroom observation protocol for undergraduate STEM (COPUS): A new instrument to characterize university STEM classroom practices. *CBE Life Sciences Education*, *12* (4), 618-627.

Souvignier, E., & Mokhlesgerami, J. (2006). Using self-regulation as a framework for implementing strategy instruction to foster reading comprehension. *Learning and instruction*, *16*(1), 57-71.

Tachie, S. A. (2019). Meta-cognitive Skills and Strategies Application: How this Helps Learners in Mathematics Problem-solving. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(5), em1702.

Teegavarapu, S., Summers, J. D., & Mocko, G. M. (2008, January). Case study method for design research: A justification. In *International design engineering technical conferences and computers and information in engineering conference* (Vol. 43284, pp. 495-503).

Tetnowski, J. (2015). Qualitative case study research design. *Perspectives on Fluency and Fluency Disorders*, *25*(1), 39-45.

Thomas, G. P. (2012). Metacognition in science education: Past, present and future considerations. In *Second international handbook of science education* (pp. 131-144). Springer, Dordrecht.

Tosun, C., & Senocak, E. (2013). The effects of problem-based learning on metacognitive awareness and attitudes toward chemistry of prospective teachers with different academic backgrounds. *Australian Journal of Teacher Education*, *38*(3), 4.

Treagust, D. F., & Duit, R. (2008). Conceptual change: A discussion of theoretical, methodological and practical challenges for science education. *Cultural Studies of Science Education, 3(2), 297-328.*

Vandenbosch, B., & Higgins, C. (1996). Information acquisition and mental models: An investigation into the relationship between behaviour and learning. *Information Systems Research*, *7*(2), 198-214.

Van Tassel-Baska, J., Quek, C., & Feng, A. X. (2006). The development and use of a structured teacher observation scale to assess differentiated best practice. *Roeper Review, 29(2), 84-92.*

Wilson, D., & Conyers, M. (2016). *Teaching students to drive their brains: Metacognitive strategies, activities, and lesson ideas*. ASCD.

Zembylas, M. (2005). Three perspectives on linking the cognitive and the emotional in science learning: Conceptual change, socio-constructivism and poststructuralism.

Zemira, M., & Bracha, K. (2014). *Educational Research and Innovation Critical Maths for Innovative Societies the Role of Metacognitive Pedagogies: The Role of Metacognitive Pedagogies*. OECD publishing.