



(RESEARCH ARTICLE)



## Investigation of constraints faced by teaching and learning of chemistry in Nyarugenge district secondary schools: Quest for quality improvement

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### Abstract

The present study investigated constraints faced by chemistry teaching and learning. It also suggested possible solutions for addressing the identified constraints. A total sample of 138 respondents including 125 students in chemistry combinations, 10 chemistry teachers and 3 directors of study were chosen purposefully to participate in this study. A qualitative research method using case study design was employed to gather necessary data. Content and thematic analysis methods were used to analyze the data. The results revealed that abstract nature of some chemistry concepts, lack of laboratory apparatus and chemicals, lack of laboratory technician to support chemistry teachers are major constraints faced by teaching and learning of chemistry. This study suggested that government and educational stakeholders should supply adequate chemicals and apparatus, chemistry teachers must use hands-on activities and video simulations to concretize chemistry concepts. Chemistry teachers should also motivate learners to enjoy chemistry to reduce negative attitude of students towards chemistry. Lastly the recruitment of laboratory attendants was also suggested as a major strategy to support chemistry teachers in preparation of chemistry practices.

**Keywords:** Investigation; Constraints; Teaching; Learning; Chemistry

### 1. Introduction

Nowadays, Science understanding has a great impact on the development of science and technology. Through this, professional and well skilled people are needed for better science understanding. Chemistry as one of science subjects contributes to the development of industries and social well-being of people.

To produce competent and well skilled professionals in the field of chemistry education, requires a deep understanding of how chemistry is taught and how constraints encountered while teaching and learning chemistry are addressed. It is through this context, this study was designed to reveal constraints that hinder the effective chemistry teaching and learning towards searching alternative strategies to address them.

According to Mcgrath [1], the main aim of educational system in any country is to develop people's confidence and competences that can enable them to apply both knowledge and skills acquired in transforming their lives and participate in socio-economic development of the country. Additionally, educational system helps in the development of human skills and knowledge and it is the key leading to national development [2]. The prime minister of Rwanda Dr. Edouard Ngirente in February, 2018 insisted on these by saying that quality education is a government priority and to

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achieve improved quality education, we need to address all the challenges that hinder it. He added that quality education is one of government priorities in 7- year programs (2017-2024) and it would contribute to making Rwanda, a knowledge-based economy country [3]. Quality of science teaching is being focused on in Rwanda.

The study conducted by Kibui [4] revealed that chemistry is individuality subject that can contribute in country' development when focused on how chemistry skills are applied in daily life. Teaching sciences and technological based subject needs to invest in searching facilities such as laboratories, chemicals in addition to common teaching aids like chalks, chalkboard and books [5]. To achieve effective chemistry teaching, teacher should understand the purpose of chemistry education in schools and these help him to set learning objectives according to the desired goals [6].

Lerman [7] stated that innovative approaches for teaching and learning chemistry has been advanced for all levels and in curriculum setting to attract students to learn chemistry. The research conducted by Muhammad [8] concluded that changing methods of teaching from lecture to innovative learning and development of practical equipment from local available materials enhance chemistry teaching and learning. Even though progress on improving the learning conditions in schools are being made, many programs relating to chemistry education fail to achieve desired goals due to different constraints encountered during program's implementation [9].

According to Umeriz and Mossio [10], a constraint is anything that imposes a limit, a restriction or prevents something from occurring effectively as planned. Pia findings classified constraints to teaching and learning into systematic constraints, pedagogical constraints and social constraints [11]. Systemic constraints to learning are constraints created by the education system itself. These include overcrowding in classrooms, inappropriate language of learning and teaching, insufficient training of educators to manage diversity in their classrooms and lack of teaching assistants [12]. On the other hand, pedagogical barriers are linked to teacher pedagogical skills, teaching styles and teaching aids [13]. Social constraints are linked to social life of learner, family background and parental involvement in students' learning.

This study was aimed at investigating constraints faced by teaching and learning chemistry for the purpose of searching alternative strategies to address identified constraints to improve the quality of chemistry teaching and learning. The emphasis was put on what advanced level students and chemistry teachers suggested for effective chemistry teaching and learning.

The following research questions guided this study for better revealing main constraints advanced level students and chemistry teachers encounter during chemistry teaching and learning process:

- What are the main constraints faced by students during teaching and learning chemistry in Nyarugenge district?
- What are the main constraints faced by teachers during teaching and learning chemistry in Nyarugenge district?
- How constraints encountered by both teachers and students while teaching and learning chemistry should be addressed in Nyarugenge district?

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## 2. Research methodology

Basing on explanations suggested by Igwenagu [14] about research methodology, this section describes how research process was done.

In this study, the case study research design was employed to reveal constraints faced by chemistry teachers and students while studying chemistry. An interpretivism paradigm with an inductive approach helped to analyze data as it focuses on the truth found in respondents. The study was conducted in three selected secondary schools of Nyarugenge district in Rwanda. The selection of those three schools was based on the availability of chemistry combination and school status. The school chosen might hold chemistry combination, being public and hold both girls and boys.

Different methods were used to collect data for triangulation purpose. Questionnaire with open ended questions, an interview schedule and observation were used as the main methods of data collection. The gathered data was analyzed using thematic and content analysis. The validity and reliability of the research instruments was tested by a pilot study conducted on 20 respondents prior to data collection. The sample was composed of 138 respondents that was chosen purposively. It included 125 learners, 10 chemistry teachers and 3 directors of studies (DOS).

**Table 1** Characteristics of respondents based on gender

Gender	Position	Number of respondents	Percentage
Male	Director of studies	1	0.72%
	Chemistry teacher	6	4.34%
	Student	65	47.11%
Female	Director of studies	2	1.45%
	Chemistry teacher	4	2.90%
	Student	60	43.48%
Total		138	100%

The participant identification was confidential. The consent form signed before data collection emphasized on anonymity and confidentiality issues.

### 3. Research findings and discussion

#### 3.1. Constraints faced by chemistry teaching and learning gathered from students' responses

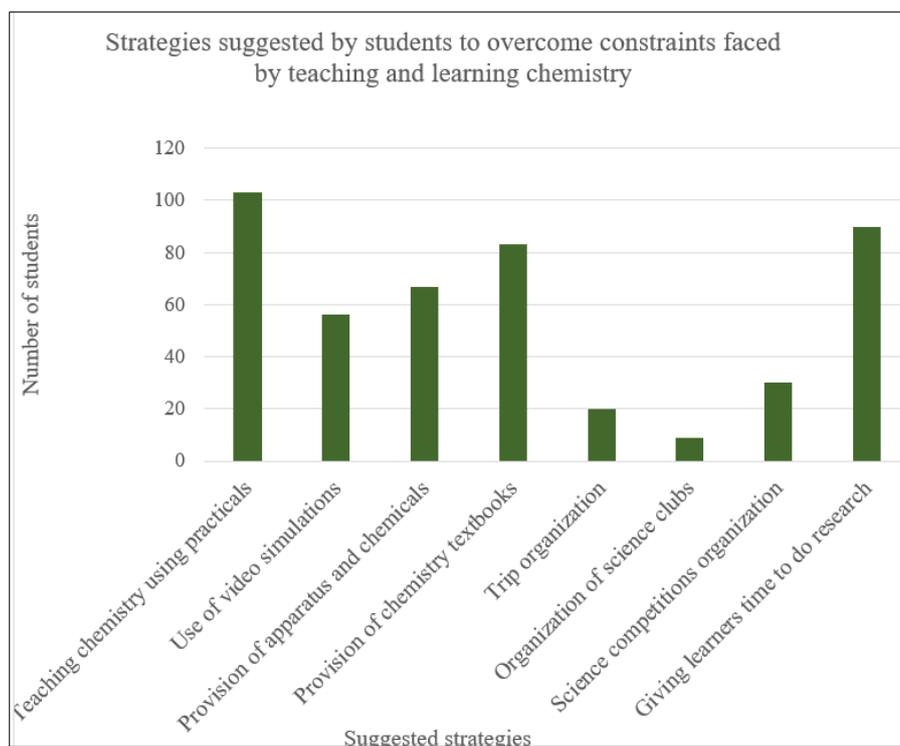
Basing on students' responses and Pia [11] findings, 3 main themes have been developed to categorize constraints faced by chemistry teaching and learning. The main themes developed classified constraints to teaching and learning into systematic constraints, pedagogical constraints and social constraints. In each theme, sub-themes have been developed according to students' responses. Students' responses revealed the following constraints as presented in Table 2.

**Table 2** Constraints faced by teaching and learning of chemistry from students' responses

No.	Constraints	Number of respondents out of 125	Percentage	Example of relevant quotes raised by participants
<b>Systematic constraints</b>				
1	Length of chemistry lesson	20	16%	Some chapters remain uncovered in a year
2	Absence of trips	15	12%	We need to do field trips for example visiting SULFO to see how a soap is made.
3	Abstract nature of some chemistry concepts	39	31.2%	Teacher explains some concepts and it is sometimes difficult to understand them because it is difficult to put them in real life, for example an electron.
4.	Shortage of classroom assessments	50	40%	We need many assignments as much as possible.
5.	Curriculum changes	1	0.8%	For me, the change that has been done in chemistry curriculum affected my

					performance. In ordinary level I learned in a system that is different from that we are using in advanced level.
<b>Societal and environmental constraints</b>					
6.	Students 'attitudes towards chemistry	Easy	37	29.6%	I don't perceive chemistry teaching difficult because I have a coach who help me to do researches and exercises at home. I can advise my colleagues to do researches and avoid bad choice of combination
		Difficult	67	53.6%	We do not carry out experiments. So it is difficult to practice what we have learned in chemistry in our daily life.
		No comment	21	16.8%	I choose no comment because some units are easy and others are difficult.
7.	Application of chemistry in daily life		18	14.4%	When I am studying chemistry, I think on its application in our daily life and I find that it is difficult to apply it. Teacher should encourage us by showing the applications of chemistry in daily life.
8.	Economic status of parents		12	9.6%	My family is poor, I do not get all basic materials like calculator and periodic table.
<b>Pedagogical constraints</b>					
9.	Lack of motivation from teachers		52	41.6%	I need the advices of chemistry teachers to understand difference tips for succeeding chemistry.
10.	Shortage and absence of teaching materials		71	56.8%	There is no enough books for reading chemistry concepts.
11.	Teaching chemistry in theories without practices		91	72.8%	-We don't do many practices; we just learn theories. Sometimes we

				may believe that what we learn are not possible in real life and it has no use. -Practice increases understanding. When experiments are performed many times, we get motivated to learn and understand more concepts.
12.	Absence of laboratory apparatus and chemicals	73	58.4%	In our laboratory, there are not enough apparatus and chemicals to use in different practices.
13.	Language barrier	23	18.4%	Sometime when chemistry teacher is explaining in English I don't understand. He should mix with Kinyarwanda for better understanding.
14.	Absence of time to do chemistry researches	84	67.2%	In class timetable, there should be specific hours reserved for research.



**Figure 1** Strategies suggested by learners to overcome constraints faced by chemistry teaching and learning

### 3.2. Strategies suggested by learners to overcome constraints faced by chemistry teaching and learning

#### 3.2.1. Teaching chemistry by using practical work in laboratory

This strategy was raised by 103 students out of 125 students participated in the study. One student's respondent stated that "*MINEDUC and REB should make a rule of having at least two periods of practice per week*". That quote was raised by one of student to show that practices are necessary in chemistry teaching and learning. Chemistry practical work enhance students' interest and motivation, learning practical skills and the increase of scientific knowledge as well as giving insight into the nature of science [15]. It is clear that practice enhances students' interest and motivation through the manipulation of chemicals and apparatus.

#### 3.2.2. Use of Video simulations

56 students out of 125 (44.8%) have suggested that when practical experiments are not possible, teacher can use audio-visual simulations. In agreement to George & Kolobe[5], virtual simulations can serve as an alternative where physical laboratory equipment are lacking or absent. It is difficult to obtain all necessary chemicals and apparatus 100 per cent. Audio-visual simulations can serve as another alternative.

#### 3.2.3. Provision of apparatus and chemicals

In searching strategies for effective chemistry teaching and learning, 67 students (53.6%) stated that educational stakeholders should provide necessary apparatus and chemicals. The following idea was raised by some students. *We need laboratories well equipped by basic apparatus and chemicals for better understanding chemistry concepts.* Subotin, Druta, Dragancea, & Haritonov[16] stated that chemistry has an experimental character and it is better to teach it using practical experiments. To achieve this, it is better to provide basic requirements for doing practical activities. That's why MINEDUC and REB should provide basic apparatus and chemicals in all schools with chemistry combinations to enhance the effective teaching and learning of chemistry.

#### 3.2.4. Provision of chemistry textbooks

Textbooks are the first resources where students get specific information. One student respondent highlighted the following concern regarding to textbook provision. *What I can suggest to address constraint of lacking textbooks, educational stakeholders should provide enough books for students to facilitate research and self-studies.* Not only this respondent, 66 per cent of students' respondents suggested that having enough chemistry books is one of the ways to help them in their own studies and researches.

Considering the study conducted by Robinson, Fischer, Wiley, and Hilton [17] about the impact of textbooks on science outcomes which concluded that textbooks can be used to improve learning outcomes, the recommendation of these students is adequate for enhancing chemistry teaching and learning as well as students' performance.

#### 3.2.5. School Field Trip organization

16 per cent of students' respondents raised the issue of doing field trips as one of the ways to understand the usefulness of chemistry in daily life. One student stated that "*we need field trips like visiting SULFO to see how a soap is manufactured*". Behrendt & Franklin [18] in their paper highlighted the importance of field trips in education. They stated that field trips provide immediate experience, stimulation of interest and motivation in science, addition of relevance to learning, strengthening of observation and perception skills as well as promoting personal development. These stipulate that trips organization in chemistry teaching and learning process, will save as motivation to students to examine the application of chemistry knowledge in the society around them.

#### 3.2.6. Organization of science clubs in schools

In the study conducted by Hartley [19] about science clubs as a tool to promote science communication activities, he found that science clubs help in the understanding of contemporary issues in science, promotion of the ability to relate science with daily life events and development of confidence in conducting practical activities. In agreement to the study of Hartley, one student insisted that *the inauguration of science clubs in schools and research based project can encourage learners to like and perform better in science especially chemistry by also relating science in daily life.* 9 students (7.2%) suggested the idea of science clubs' organization in schools to address challenges faced by chemistry teaching and learning and this can be helpful in developing positive attitudes of students towards chemistry as well as science in general.

### 3.2.7. Science competition organization

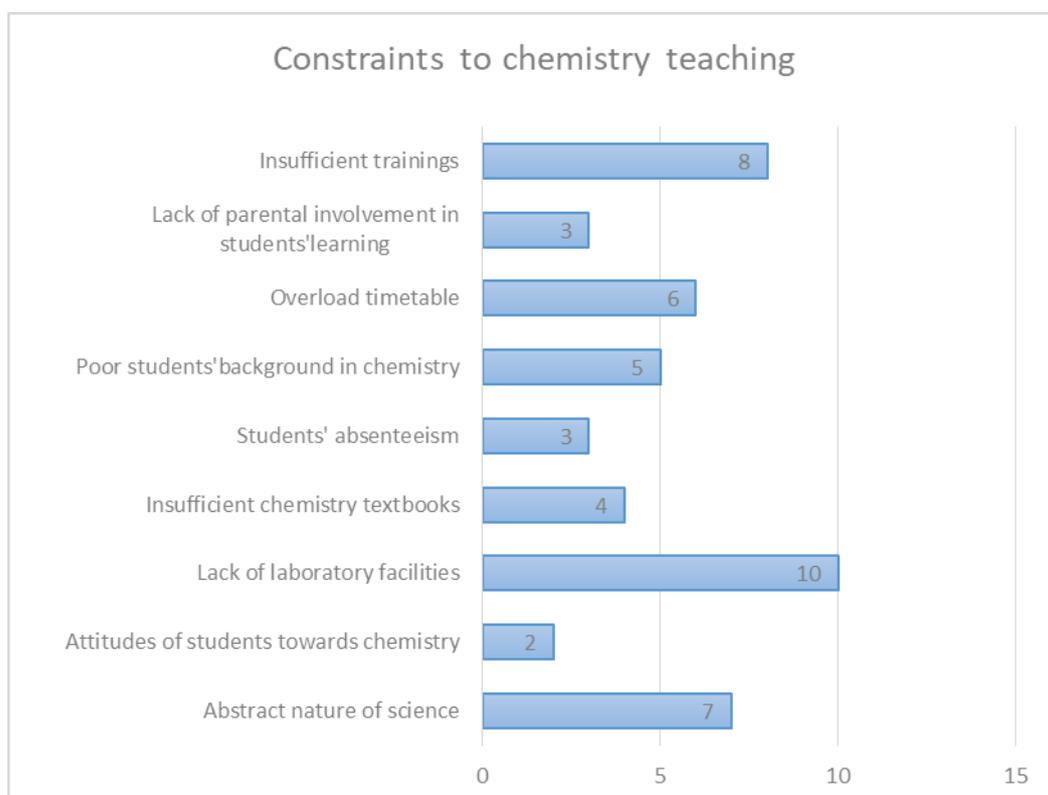
Among 125 students that filled the questionnaire, 30 students suggested this idea of organizing science competitions to motivate them liking sciences. The observation made by Verhoeff [20] in his study about the role of competitions in education revealed that competitions can be a good measure of how a discipline integrated into curriculum is accepted. In agreement to that observation of Verhoeff, one student said *“I recommend REB and MINEDUC to organize science competition and research based projects to identify how we perform in sciences.”*

### 3.2.8. Giving learners time to do research

71.8 per cent highlighted that allowing them time to do research can enhance their understanding of some chemistry concepts. One of them said *“I need enough time to make research in chemistry for enhancing my understanding of some chemistry concepts”* Research is the source of knowledge and it increases critical thinking in the learners. Stafford [21] in his article about integrating research in classroom instructions, he indicated that students need an opportunity to reflect on their learning, and to examine their own learning over a long period of time by doing researches. As highlighted by students in this study, allowing them to do researches related to chemistry subject can heighten their understanding about chemical phenomena.

### 3.3. Constraints faced by chemistry teaching and learning from teachers' responses

By analyzing teachers' responses, the following constraints (Figure 2) have been identified:



**Figure 2** Summary of constraints faced by teaching and learning chemistry from chemistry teachers' responses

It is clear that lack of laboratory facilities, insufficient trainings and abstract nature of science are the major constraints raised by chemistry teachers.

From teacher's questionnaire and interview guide, the following constraints (Table 3) were observed as well as possible strategies.

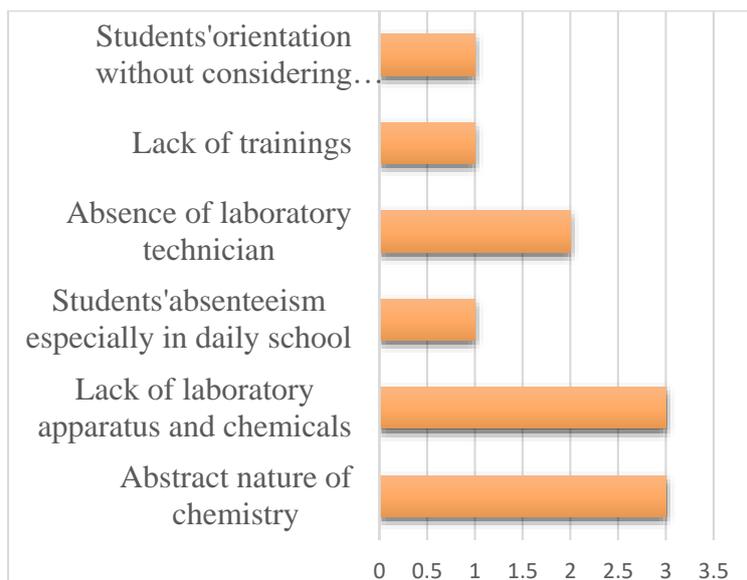
**Table 3** Constraints faced by chemistry teaching and learning extracted from teachers' responses with some of their quotes.

Chemistry teacher	Theme clarifying the constraint	Typical example of relevant quote	Suggested strategies
Teacher A	Abstract nature of chemistry Overload timetable Absence of trainings Insufficient textbooks Absence of laboratory chemicals and apparatus	My timetable has many periods without free time to prepare practical	Recruitment of laboratory technicians Reserving periods for practices Providing sufficient chemistry textbooks
Teacher B	Students' absenteeism in chemistry classes Overload timetable Absence of laboratory facilities Absence of trainings	In our school, we have laboratory but there are few chemicals especially those for organic compounds.	Providing adequate laboratory chemicals and apparatus
Teacher C	Lack of parental involvement in students' learning Absence of laboratory facilities Absence of trainings	Parents do not provide all necessary facilities for learners. They let students to study without follow up	Parental involvement in students' learning Providing laboratories with skilled laboratory technicians
Teacher D	Abstract nature of chemistry concepts Poor students background in chemistry Abstract concepts in chemistry Absence of laboratory chemicals and apparatus	Some chemistry concepts are abstract for example electrons.	Use of audio-visual simulations Career guidance while students are in choice of combinations
Teacher E	Lack of laboratory chemicals and apparatus Students' attitudes towards chemistry Overload timetable Abstract nature of chemistry Absence of trainings	Most of my students believe that chemistry is a difficult subject because some concepts are abstract to explain them in reality	Improvisation of teaching aids Use of audio-visual simulations Motivating students while teaching them
Teacher F	Overload timetable Lack of some chemicals Abstract concepts in chemistry	My timetable do not permit me to carry out experiments	Employment of laboratory attendants Reserving time for preparing practical activities
Teacher G	Absence of trainings Absence of laboratory chemicals and apparatus Abstract concepts in chemistry	Most of required chemicals are absent in our laboratory	Use of Simulations when chemicals and apparatus are absent. Providing basic ICT facilities for using simulations

	Absence of trainings Students' attitudes towards chemistry		Improvisation of teaching aids where necessary Providing sufficient trainings on chemistry teachers
Teacher H	Absence of time to prepare practical Absence of laboratory chemicals and apparatus Overload timetable Students' background in chemistry	I have an overload timetable and having a laboratory technician can help me in preparation of solutions	Use of laboratory technician to support science teachers
Teacher I	Abstract concepts in chemistry Absence of trainings Absence of laboratory chemicals and apparatus	No time to prepare practical lesson	To reserve time for preparing practices Availing necessary chemicals
Teacher J	Abstract concepts in chemistry Overload timetable Absence of laboratory chemicals and apparatus Absence of trainings	Chemistry is somehow abstract in nature	Improvisation Use of simulations Provision of ICT tools to support simulations

### 3.4. Constraints faced by chemistry teaching and learning from directors of studies' responses

Figure 3 summarizes constraints faced by teaching and learning chemistry from DOS responses.



**Figure 3** Constraints faced by chemistry teaching and learning from directors of studies responses

The directors of studies in selected schools suggested what can be done to address constraints faced by teaching and learning of chemistry (Table 4).

**Table 4** Constraints faced by chemistry teaching and learning with suggested strategies basing on directors of studies responses

Director of study	Constraints raised	Proposed strategies to address them
Director of study in school A	-Abstract nature of chemistry -Insufficient and lack of laboratory apparatus and chemicals - Students' absenteeism especially in day school - Absence of laboratory technician	Use of audio visual simulations Provision of necessary chemicals and apparatus Taking into account students' attendance Recruitment of laboratory technician for supporting chemistry teachers
Director of study in school B	-Insufficient continuous professional development for chemistry teachers -Lack of laboratory apparatus and chemicals -Some technical terms are abstract to understand - Students' orientation in combinations without taking into account their grades in science subjects from ordinary level exam which affect their performance.	Providing many continuous trainings for teachers especially those of science -Equip schools with enough materials: Chemistry laboratories well equipped. - Orientation of students should be based on their abilities. -Regular training for Headteachers and directors of studies so that they can assist science teachers.
Director of study in school C	-Lack of laboratory apparatus and chemicals -Abstract nature of chemistry -Absence of laboratory attendants	If possible for strengthening the quality of chemistry teaching and learning, REB and MINEDUC should provide basic laboratory equipment and chemicals and recruit laboratory technician to support chemistry teachers.

Source: Researcher, primary data based on interview responses with DOS

#### 4. Conclusion

Taking into account the findings drawn from the study, Constraints faced by chemistry teaching and learning were categorized into systematic constraints, pedagogical constraints and social constraints.

Pedagogical constraints identified include lack of adequate practical periods, inadequate laboratory facilities (including chemicals and apparatus), lack of laboratory technician to support chemistry teachers, motivation, insufficient chemistry textbooks, inadequate teaching and learning aids, lack of adequate training for chemistry teacher and language barrier.

Among the systematic constraints highlighted by respondents, abstract nature of some chemistry concepts, length of chemistry curriculum, lack and shortage of chemistry teaching materials, absence of laboratory assistants and overload timetable for chemistry teachers are the main constraints raised.

Social constraints identified include, students' attitudes towards chemistry, students' background in chemistry subject, lack of parental involvement in students' learning, students' absenteeism especially in day schools and socio-economic status of parents.

Basing on the highlighted constraints, this study revealed the following recommendations to address the identified constraints as well as improving the quality of chemistry teaching and learning:

- As practical is a key component for chemistry subject. Then there should be well-equipped laboratories with adequate chemicals and necessary facilities such as water system, electricity, fire extinguisher and first aid kit.

In case chemicals are absent, virtual simulations can serve as an alternative where physical laboratory is absent [5].

- Employment of competent laboratory assistant to support chemistry teachers in the preparation of laboratory practical. This will promote the effective teaching and learning of chemistry by decreasing teacher's overloads.
- Provision of relevant and sufficient chemistry textbooks for both teachers and students will also promote effective chemistry teaching.
- The use of chemistry project based learning and organization of science competitions will increase students' motivation as well as the improvement of quality of chemistry teaching and learning.
- The effective integration of ICT in chemistry teaching and learning. This will help to use audio-visual simulations where real practical is not possible. It will also enhance the research culture in students.
- Increasing continuous professional development, seminars and workshops for chemistry teachers to increase their professional skills.
- Integration of ICT tools in chemistry teaching and learning to facilitate learners to do more researches.
- Improvisation of chemistry teaching aids.
- Integration of basic chemistry concepts in primary school's curriculum to enhance chemistry background of students.
- Motivate learners to like chemistry by rewarding best performers and demonstrating the usefulness of chemistry in daily life.
- Reserving periods of doing practical experiments on school timetable to enhance practices and hands on activities.
- Promoting learners in chemistry combinations by taking into account their performance in chemistry subject from ordinary level.
- Sensitizing parents to take part into their students' learning

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## 5. Suggestions for further studies

Due to time limitation, covid-19 pandemic and funds limitation, this research focused only on public schools located in Kigali city. Other researchers may repeat this study by focusing on rural area schools.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

During the whole research process, no conflict of interest arises.

### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study.

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