Teachers' and students' perceptions towards the utilization of formative assessment rubric for supporting students' learning of organic chemistry

Ezechiel Nsabayezu•, Aloys Iyamuremye•, Janvier Mukiza•, Jean Claude Habimana•, Agnes Mbonyiryivuze•, Emmanuel Gakub•, Theophile Nsengimana•, Francois Niyongabo Niyonzima•

Abstract

This study aimed to investigate the use of formative assessment rubrics for supporting the learning of organic chemistry in secondary schools in Rwanda. A mixed research approach was used to collect and analyze data. The target population was 210 senior five chemistry students and 15 chemistry teachers. However, 140 senior five chemistry students and 10 senior five chemistry teachers were purposively selected to participate in the study. The qualitative data were obtained from the interview while quantitative data were obtained from the survey questionnaire. The qualitative data were analyzed by discourse and interpretive approaches while quantitative data were checked by descriptive statistics.

• African Centre of Excellence for Innovative in Teaching and Learning Mathematics and Sciences (ACEITLMS), University of Rwanda-College of Education (UR-CE), Rukara Campus, Rwanda; ORCID: https://orcid.org/0000-0002-1377-9266; Corresponding Email: ezechielnsabayezu109@gmail.com
• African Centre of Excellence for Innovative in Teaching and Learning Mathematics and Sciences (ACEITLMS), University of Rwanda-College of Education (UR-CE), Rukara Campus, Rwanda; ORCID: https://orcid.org/0000-0003-3968-8757; Email:aloysiyamuremye@gmail.com
• University of Rwanda-College of Education (UR-CE), School of Education, Rwanda, Department of Mathematics, Science and Physical Education ORCID Number: https://orcid.org/0000-0003-3191-9493; Email: janvier.mukiza@gmail.com
• African Centre of Excellence for Innovative in Teaching and Learning Mathematics and Sciences (ACEITLMS), University of Rwanda-College of Education (UR-CE), Rukara Campus, Rwanda; Email: habiclaude1994@gmail.com
• African Centre of Excellence for Innovative in Teaching and Learning Mathematics and Sciences (ACEITLMS), University of Rwanda-College of Education (UR-CE), Rukara Campus, Rwanda; Email: mbonyiryivuzeagnes@yahoo.com
• University of Rwanda-College of Education (UR-CE), School of Education, Rwanda, Department of Mathematics, Science and Physical Education Email: egakuba16@gmail.com
• University of Rwanda-College of Education (UR-CE), School of Education, Rwanda, Department of Mathematics, Science and Physical Education Email: nsengimanafr@gmail.com
• University of Rwanda-College of Education (UR-CE), School of Education, Rwanda, Department of Mathematics, Science and Physical Education Email: niyofra@yahoo.com

The results of this study showed that from rubric formative assessment, students understood instructors' expectations and encouraged individual learning. The students' knowledge retention was also increased. The instructors mentioned that they were able to grade the students' tasks fast with the help of an analytic rubric and good formative feedback was availed to students on time. The students were satisfied with the use of the formative assessment rubric and they affirmed that they were motivated and engaged in learning organic chemistry. It was recommended that chemistry teachers should use rubrics during formative assessment in organic chemistry.

Keywords: Formative assessment rubrics, students' learning, organic chemistry, motivation, performance.

1. Introduction

A formative assessment rubric is the grading criteria that clarify the expected standard for the achievement of a given activity. Rubrics make the learning objectives clear, makes grading more perfect and fair to promote students' learning (Andrade, 2005), and help students with self and peer assessment (Williams & Seddon, 2017). The study conducted on rubric-based formative assessment in portfolio process towards self-regulated learning revealed that rubrics have facilitated students to be active learners by promoting self-reflection and accountability in their learning (Tur *et al*., 2019). Another research conducted on students' perspectives on rubric-referenced assessment revealed that the use of rubrics in assessment potentially supports student performance (Andrade, 2005). In a focused group, learners expressed that rubrics helped them to focus on the expected ideas in their works and they produced an assignment of better quality and good grades (Andrade, 2005; Idris *et al*., 2017). For the study carried out in one of the public secondary schools in Brunei country located in South East Asia, the students were given work at the same time with rubrics, and the results proved that the rubrics enhanced learners' thinking skills, peer and self-assessment. The students were confident and motivated when doing their work because they knew the instructors' expectations (Idris *et al*., 2017).

In the context of Rwanda, one study on rubric-based formative assessment to support students' learning of organic chemistry in the selected secondary schools in Rwanda was conducted by Nsabayezu et al. (2012). It showed that through the use of rubrics, the students comprehend instructors' expectations, and their learning was improved, as well as knowledge retention was also greater than before. A rubric is thus crucial in this twenty-first century for self-oriented learning and students' self-assessment of the planned learning achievement.

Instructors at every academic stage examine the importance of formative assessment rubrics in improving the students' performance in their corresponding subject. Hence, they

use analytic rubrics to assess and grade students' works, such as laboratory reports, problem-solving abilities and science literacy levels (Jensen, 1995; Lebowilz 1998; Schafer *et al*., 2001). Some researches were done on the benefits of formative assessment rubrics in enhancing learners' performance, but studies on rubrics are still few (Chowdhury, 2019). Studies on the use of formative assessment rubrics in the education area are also still insufficient (Phu-ampai, 2019). Therefore, additional researches should be carried out to explore the effect of using formative assessment rubrics on students' achievement.

Several scholars have acknowledged organic chemistry as a difficult chemistry subject (Eticha & Ochonogor, 2013; O'Dwyer & Childs, 2017). However, students who desire to pursue a profession in chemistry and medicine must have enough understanding of organic chemistry (Treagust *et al*., 2018). The difficulties of organic chemistry hinder several students to continue their studies in a career where organic chemistry is taught (Eticha & Ochonogor, 2013). Various studies showed that organic chemistry is a difficult subject for students who pursue their education in this career, but the reason for difficulty may vary from one person to another (Treagust., 2018). The difficulty of organic chemistry for students is caused by teaching methods and teachers` lack of accurate awareness of their pupils' prior knowledge, misconceptions and there is no set of rules for solving problems. Therefore, the formative assessment rubrics in supporting secondary school students' progressive learning in organic chemistry should be one of the solutions.

2. Research questions

This research was guided by the following questions:

1. What are the students' perceptions of the use of formative assessment rubrics during their learning of organic chemistry in secondary schools in Rwanda?
2. How does the use of formative assessment rubrics support students' progressive learning in organic chemistry in secondary schools in Rwanda?

3. Methodology

The present study used a mixed research approach where the qualitative and quantitative data were called. A sample of 150 participants comprising of 140 students and 10 chemistry teachers selected on purpose from two secondary schools in Nyarugenge District of Rwanda was considered. The schools were selected based on the criteria that they are utilized as the site/center for the national examination. The students were taught the unit of organic chemistry namely, alkanes, alkenes, alcohols, carboxylic acid and ethers by the chemistry teacher. The students were trained on how to use a formative assessment rubric. Hence, every participant was assigned activities followed by a formative assessment rubric. The developed analytic rubrics were shared with students at the same time as assigned learning tasks. The learning tasks were solely related to the unit of organic chemistry. Every student

had time to present his/her findings on every assignment done and each presentation was marked referring to the provided rubric. In this way, the analytic rubrics were adopted in this study. This was done in three successive months. Afterwards, chemistry teachers and students were interviewed. The focus group interview was used to collect qualitative data. Additionally, questionnaires, which consisted of a set of questions aimed at collecting quantitative data, were also used. The questionnaire used contained 18 closed items to investigate the use of formative assessment rubrics in supporting secondary school students' progressive learning in organic chemistry. Besides, the questionnaire had also six open-ended items related to benefits and challenges experienced by chemistry teachers and students during the use of formative assessment rubrics while learning organic chemistry.

4. Ethical considerations

The participants of this study had time to sign the consent form. The anonymity and confidentiality of the respondents were preserved by not disclosing their identification in the collection of data, data analysis and presentation of findings. The interview environment and the identification of the respondents were private. The data were stored in a coded and locked computer, flash disk, memory card and even on the email of the researcher. The hard copies were kept in a locked room without access to everyone.

5. The rationale of the study

Through the findings of this study, students will improve self-confidence, motivation and a positive attitude toward organic chemistry learning. The current study will improve the instruction process. In addition to supporting students' progressive learning in organic chemistry and improving assessment strategies, the findings of this study will also help the instructors to be systematic when planning and assessing learners' activities. It will encourage students to be the owner of learning by developing critical thinking, self-assessment and improving the quality of their activities. The results of this study will also contribute to the existing literature on chemistry assessment approaches for future use by different researchers after publication.

6. Results and Discussion

This part represents the results and discussion revealed from the gathered data. The informed results are about students' perceptions of the use of formative assessment rubrics during their learning of organic chemistry; and the eeffectiveness of formative assessment rubrics in supporting students' learning of organic chemistry. The results are represented in the figures, and frequencies, percentages, variances, standard deviations and means were shown.

6.1 Students' perceptions towards the use of formative assessment rubrics during their learning of organic chemistry.

The figure 1 shows the results from five questions asked to explore the students' perceptions of the use of analytic rubrics during formative assessment in organic chemistry.

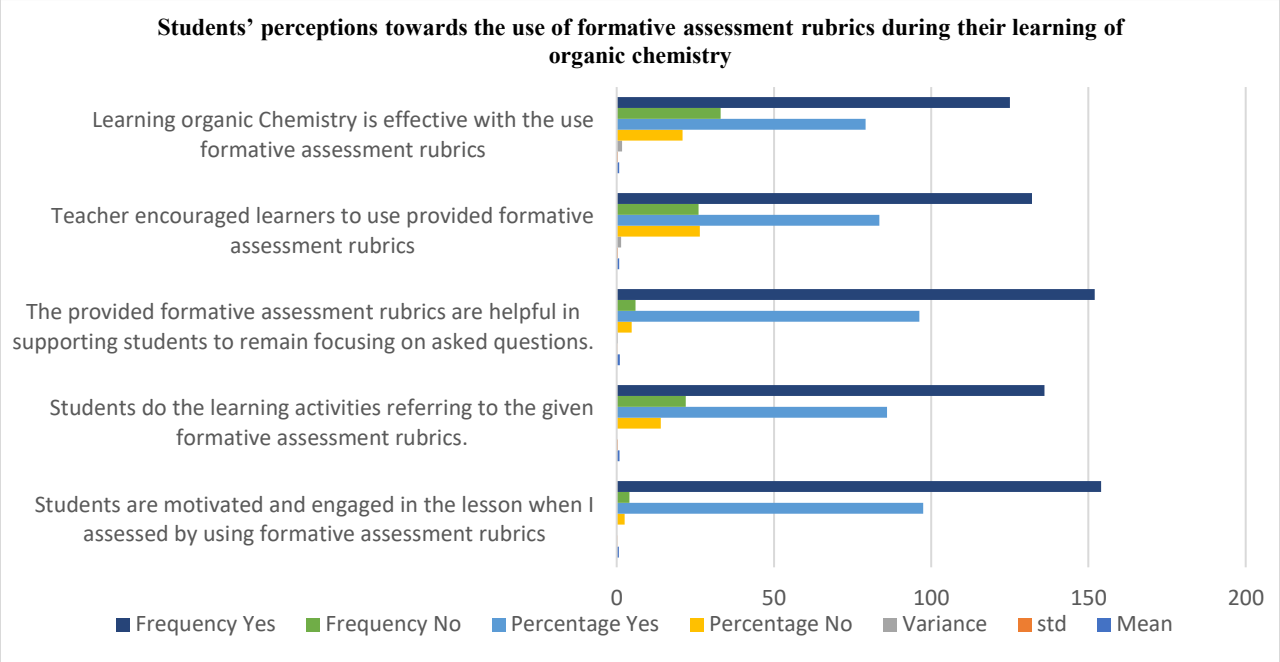

Fig 1. Students' perceptions towards the use of formative assessment rubrics during their learning of organic chemistry

The results in the figure 1 show that all contestants liked to be assessed with the help of formative assessment rubrics. 97.47% of the participants affirmed that they were motivated and engaged in learning organic chemistry. They added that when they accessed rubrics, they recognized the teacher's expectations. 96.2% reported that the instructions from the teacher helped support them to keep focusing on learning tasks while 86% expressed that they liked to do their learning activities referring to the provided formative assessment rubrics. 83.54% indicated that the teachers encouraged them to explore the provided formative assessment rubrics. 79.11% of the participants reported that learning organic chemistry was effective with the use of formative assessment rubrics. The majority of students confirmed that they were satisfied with the use of formative assessment rubrics in organic chemistry. They added that this helped to recognize the grade assigned to each level of accomplishment. The learners agreed that the provided formative assessment rubrics were effective to support their progressive learning in organic chemistry

The obtained findings on students' perceptions towards the use of formative assessment rubrics during their learning of organic chemistry are in agreement with the results of a study conducted by Chowdhury (2019) on the application of rubrics in the classroom, an

important tool for improvement in assessment, feedback and learning. He found that rubrics clearly define what is expected and what will be graded either in a virtual or physical class. It specifies that the evaluation will be agreed to specified criteria. With the aid of rubrics, learners openly understand the requirements to get good marks in a given learning activity. The results of the present study are also in good agreement with the research done on rubrics as assessment, evaluation and scoring tools. This study revealed that rubrics help learners to relate what they learned and what they are doing in the assessment and they become motivated and engaged in their learning. Yet, they help to remove many claims which can arise when students receive feedback from teachers (Muhammad *et al.*, 2018). The findings of the current study are also in agreement with the study conducted by Anglin *et al*. (2008) on improving the efficiency and effectiveness of grading through the use of computer-assisted grading rubrics.

To support the asked questions, the participants were requested to express how the use of formative assessment rubrics supported their progressive learning of organic chemistry. 97.2% highlighted that rubrics assisted them to recognize instructors' expectations, helped them to plan their learning, and promote their self-assessment and peer-assessment. They added that the use of rubrics promoted their learning by recognizing their weak point and monitoring their learning. In addition, they expressed that the use of formative assessment rubrics supported their learning; however, they needed enough time to be familiar with it. These results are in the same line with the findings of the study conducted by Chen *et al*. (2013) on the development and application of scoring rubrics for evaluating students' experimental skills in organic chemistry which revealed that the utilization of rubric materials helps to identify the students' weakness and strengths about the performance of chemical experiment (Chen *et al*., 2013).

6.2 Use of formative assessment rubrics supports students' progressive learning in organic chemistry in secondary schools in Rwanda

The following are results of the use of formative assessment rubrics to support students' progressive learning in organic chemistry in secondary schools in Rwanda. The asked items were related to the effectiveness of formative assessment rubrics in supporting students' learning of organic chemistry that results in supporting students learning of organic chemistry. The effectiveness of formative assessment rubrics in supporting students' learning of organic chemistry was investigated as shown on the figure 2.

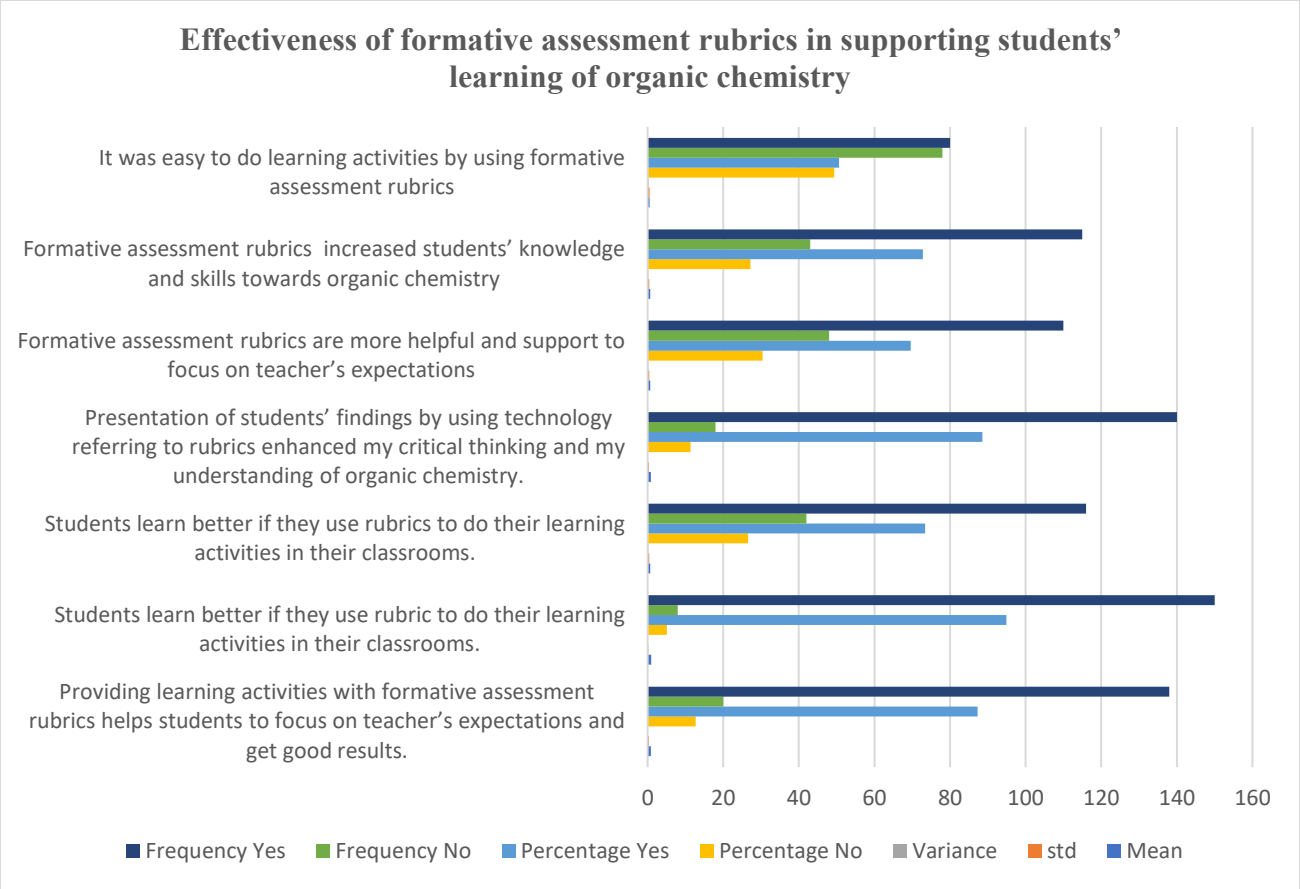

Fig 2: Effectiveness of formative assessment rubrics in supporting students' learning of organic chemistry

A good level of affirmation about the effectiveness of formative assessment rubrics in supporting secondary school students' progressive learning in organic chemistry was observed (Fig. 2). The responses on the asked seven items related to the effectiveness of formative assessment rubrics in supporting students' learning in organic chemistry show that 67.3, 85.3, 90.9, 70.4, 89.6, 71.62, 76.78, and 51.63% affirmed that formative assessment rubrics support secondary school students' progressive learning in organic chemistry. In addition, the contestants were asked what they enjoyed about formative assessment rubrics. For this statement, 87.8% of participants mentioned that their critical thinking was enhanced while using formative assessment rubrics to answer the asked questions. Rubrics improve learning and collaboration between students and instructors, promote active learning as well as accelerate the exchange of content and information. These results on the use of formative assessment rubrics to support students' progressive learning in organic chemistry in secondary schools in Rwanda agree with the reported study on the role of rubrics in testing and teaching which mentioned that rubrics are used to grade the quality of learners' works, make scoring more systematic and enhance students' knowledge retention (Popham, 2006). Indeed, rubrics inspire learners to reflect on their learning

advancement and facilitate teachers to modify the teaching approaches for addressing learning gaps where applicable (Muhammad *et al*., 2018). Nsabayezu, *et al*. (2022a) stressed that through the use of rubrics, the students comprehended instructors' expectations, their learning was improved, as well as knowledge retention was also greater than before. The rubric is crucial in this twenty-first century for self-oriented learning and students' self-assessment of the planned learning achievement (Nsabayezu *et al*., 2022b). The findings in this study are also in the same view as the findings of the study conducted by Andrade and Du (2005), who questioned 14 students after they utilized rubrics in class for solving tasks. Most of the participants replied that rubrics facilitated them to generate excellent work and got good marks in the learning tasks.

The study conducted about students' perspectives on rubric-referenced assessment showed that rubrics help to clarify learning approach and assignment, and students can check their learning progress by reflecting on what they are expected to do as they are written in rubrics (Andrade, 2005). The study conducted by Fay *et al*. (2007) on the rubric application to characterize inquiry in the undergraduate chemistry laboratory revealed that regular use of the inquiry rubric to direct choices in chemistry laboratory teaching facilitates students in selecting laboratory experiments.

6.3 Interview results

It was observed that formative assessments were done regularly. However, the students did not get rubrics for explaining the teacher's expectations and it seems that students did not recognize what the teacher wanted in their works. From observation, it has been realized that the majority of chemistry teachers who participated in this study did not share with students the rubrics at the time of classroom formative assessment. The students were interviewed to probe the effectiveness of accessing formative assessment rubrics during formative assessment. 90.71% of the interviewed students demonstrated that the use of formative assessment rubrics during formative assessment enhanced their critical thinking. They also expressed that they were aware of the expectations of instructors. They added that this method enabled them to learn and do self-assessments at any time and any place.

The students were also interviewed to identify the added value of using rubrics during formative assessment and the related challenges. 80.21% of them highlighted the added value of analytical rubrics that describe every level of achievement and identify the scores at each level. 24.79% of the participants added that the use of analytical rubrics helped them to understand the abstract learning tasks by identifying the required arguments in that work. The related challenges were identified by 79.9% of the interviewed students, who stressed that it is time-consuming and requires much attention. These results are similar to other studies which described that in teaching and learning strategies, rubrics explain educational

anticipations for learners and support in ensuring uniformity in scoring the learning tasks (Cox *et al*., 2015; Chowdhury, 2018). A well-defined rubric helps students to work co-operatively and, the effective use of rubrics in teaching science improves students' understanding and motivation toward science education (Delgado & Fonseca-mora, 2010).

Chemistry teachers were interviewed to express how the formative assessment rubric is important to them and the students, and its advantages and disadvantages. 97.27% of the participants said that rubrics helped them to clarify what they need in the students' works and easies the grading techniques. On the other hand, the students were able to include the key point in their work. The learners were actively engaged in the assessment. The use of rubrics helped instructors to be consistent in grading learners' works. It is in that perspective the rate of learners who claimed on grading strategies was minimized and they were able to do their self-assessment. They added that it should describe all levels of achievement. These results are in good affirmation with Andrade (2005) who stressed that a rubric used by an instructor to allocate marks is known as a scoring rubric, and is developed in collaboration with learners for improving the understanding and collaboration with learners, which enhances the teaching and learning processes.

Conclusion

The current study was conducted in two selected secondary schools in Nyarugenge District. Based on the findings, the study concluded that rubric-based formative assessment supports students' learning of organic chemistry. The results from the questionnaire showed that rubrics have the added value of helping students to understand instructors' expectations and making the scoring more consistent by encouraging individual learning, improving knowledge retention and engagement in learning. In addition, it was found that this approach helped the instructors to identify the strength and weaknesses of the learners and provide quick formative feedback to them, which makes the scoring techniques easy. The study was dedicated only to the unit of organic chemistry. Additional related studies to the other chemistry units are recommended.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request

Consent

Consent to participate and consent to publish) were obtained from all participants

Conflict of interest

The authors affirm that they have no conflict of interest to disclose

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