Impacts of Collaborative Learning on Learners' Academic Performance in Chemistry in Three Selected Secondary Schools of Nyamasheke District

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Abstract

Collaborative learning helps students to have active control over their own learning and create both academic and social relationships to accomplish common goals. This paper reports a quasi-experimental research that employed a pre-test and a post-test approach to investigate the impacts of a collaborative learning teaching approach on learners' academic performance in chemistry in three secondary schools purposively selected within the Nyamasheke district in Rwanda. At each school, two classes of senior two (S2) were purposively selected whereby one class was taken as a control group, while the second parallel class formed an experimental group. Thus, all the control groups comprised 128 students, while the experimental groups comprised 133 senior two students. To collect data, a pre-test and post-test were given to the students. The data were analyzed using descriptive and inferential statistics (i.e., t-test generated by Microsoft Excel 13). The results from the t-test showed [t (257) = -8.05, p = .000; p<.001] which indicates that there is a statistically significant difference in mean scores between the two groups. The null hypothesis, therefore, is rejected in favor of the alternative hypothesis to confirm that students taught using a collaborative learning teaching approach performed better in preparation and classification of oxides than those taught using traditional lecture teaching methods.

Keywords secondary school chemistry; collaborative learning; collaborative learning teaching approach; academic performance in chemistry

Introduction

Science and technology have been identified as the key to transforming the country's economy which can only be possible when they are taught with appropriate teaching and learning approach. Chemistry is one of the science subjects which is applied to many areas of the society including industries, and other professions. Chemistry is a subject of universal interest in human development with regards to the utility of its knowledge in real-life situations which is likely to be faced by many of the students (Ahmad, 2012). That's why Chemistry education is designed to shape confidence in students and equip them with the ability to adapt to the changing situations in a scientific and technological-oriented society (Nkechinyere et al., 2018). An effective teaching and learning chemistry requires strategies that allow students to interact, exchange and acquire knowledge and skills in understanding and problem-solving. Thus, one of the best strategies suitable for teaching chemistry is the collaborative learning approach.

Collaborative learning is defined as an educational approach of using groups for enhancing learning through working together

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(Smith & Macgregor, 1992). Collaborative learning is an approach in which small groups of students of different levels of ability work together whereby each member in the group is expected not only to learn what is being taught by the teacher, but one student helps group mates study (Abdulwahab, 2016). At all levels and in all countries, educational reforms highlight the requirement to use collaborative learning as a teaching and learning strategy based on the active and main role of learners (Gisbert, 2018). In the Rwandan context, Byusa et al. (2020), stressed that some of the techniques that involve active learning include conceptual changes strategies, collaborative/cooperative learning, technology-enhanced learning, inquiry-based learning, discovery learning, and think-pair-share or peer instruction. The authors added that in collaborative classrooms, the lecturing or note-taking process may not disappear but it lives alongside other processes that are based on learners' discussion and active work with the course material. Ahmad (2012) also argued that innovative teaching strategies such as inquiry-based learning, problem-solving, collaborative learning, and demonstration methods are better than traditional methods of teaching and learning sciences as well as chemistry. This study focused on collaborative learning since collaborative learning helps students to have active control over their learning and create both academic and social relationships and to accomplish common goals (Molla & Muche, 2018).

In Rwanda, the teaching and learning of science, technology, and mathematics are being highlighted to increase its economic development (Uwizeyimana et al., 2018). Despite the importance of chemistry in technologically based societies, observation of students' performance in chemistry in the secondary school certificate examination showed that a few Rwandan students performed well in the examinations (REB, 2012). The study conducted by Uwizeyimana et al. (2018) showed that the lack of sufficient infrastructure and equipment particularly in schools located in rural areas and lack of qualified science teachers, inadequate laboratory equipment, poor science background, and an inadequate number of teaching and learning resources, are some of the factors that have affected effective teaching and learning of sciences, chemistry inclusive. Therefore, the collaborative learning approach is expected to increase students' interest and enhance achievement.

Although, few studies have been carried out to examine the implementation of collaborative learning methods in teaching and learning of chemistry in Rwandan secondary schools and their effect on learners' academic performance. It is in this perspective that this study is worthy to be conducted examining the impacts of collaborative learning teaching approach on learners' academic performance in chemistry within three selected secondary schools of Nyamasheke district.

Objectives of the study

The study attempted to achieve the following specific objective:

- to assess learners' academic performance in chemistry to examine difference between the mean scores of those taught using collaborative learning teaching approach and their counterparts exposed to traditional lecture teaching method.

Research question of the study

- Is there a mean score difference in academic performance in chemistry between learners taught using collaborative learning teaching approach and their counterparts exposed to traditional lecture teaching method?

Hypotheses

H_o: There is no statistically significant difference between students taught chemistry through collaborative learning teaching approach and those taught using traditional lecture teaching methods.

Literature review and theoretical framework

Collaborative learning is a learning environment that allows active participation in the learning process (Oludipe et al., 2010). Collaborative learning helps learners to learn by collaborating with others and working together to achieve a common goal. According to Fakomogbon and Bolaji (2020), collaborative learning is viewed as an approach employed by teachers for facilitating learning and improving students' performance. Collaborative learning helps learners to share their understanding and learning experiences and helps to promote their learning performance as well as for both groups and individuals.

The lack of collaboration among students leads to poor academic achievement, low perceptions of greater social support, and low self-esteem (Uwizeyimana et al., 2018). However, the use of collaboration improves the performance of students and encourages teamwork, more retention, and promotes students to be more engaged in the learning process and transfer of knowledge (Nkechinyere et al., 2018). Collaborative learning has been used for promoting learning achievement and encourages socialization and positive interaction among students. It creates an environment for students that increase their academic performance as they learn social skills and enhances the active participation of students (Eskay, Obiyo, & Obidoa, 2012).

The theories of teaching have to be sensitive to the processes through which learners gain knowledge or how students learn. It is in this regard that the processes through constructivist teaching and learning theory have much to contribute to the study. Constructivism is a theory of learning that refers to the idea that learners construct their learning based on previous experiences. In constructivism theory, learning is an active process in which a learner uses sensory input and constructs meaning out of the world. Constructivist theory is an approach where meaningful activities are proposed to learners and the learners reflect, search and use their capacities for being creative and initiative takers (Dagar, 2016).

In constructivism theory, a learner is an active participant in the learning process, and the teacher acts as a facilitator that helps learners to create their understanding and learning (Fernando & Marikar, 2017). Thus, in the context of this study, this theory emphasized the learner-centered, learner-directed, and collaborative style of teaching and learning. Therefore, in this theory, the knowledge is created through the interaction between teacher and learner, and within students themselves. Constructivism is expected to be an important learning theory that teachers will use to help their learners to learn chemistry effectively through the use of collaborative learning.

Methodology

Research design and population

This is a quasi-experimental research design that was conducted in three schools: G.S Saint Joseph Nyamasheke, G.S Mbuga, and G.S Saint Paul Tyazo. A quasi-experimental research design determines the cause-effect relationships between independent and dependent variables (Milun, Pervan, & Brako, 2005). The population of the study was all secondary school chemistry students enrolled in the Nyamasheke district.

Sample and sampling procedures

Based on learners' academic performance of different schools, three schools were purposively selected from three categories of

levels of schools' performance (top performer, middle performer, and low performer) in national examinations, academic year 2020. The district has 56 public secondary schools. Since we could not cover all schools, we randomly chose one school in each category of levels of performance to represent other classes in each category. At each school, two parallel classes of senior two were purposively selected, whereby one class was taken as a control group, while the second parallel class formed an experimental group. Thus, the obtained sample was made of 128 students in the control group, and 133 students in the experimental group to get a total of 261 students involved in the study. At each school, an experimental group was taught with collaborative learning, while the control group was taught with traditional lecture teaching methods.

Data collection methods

To investigate the impacts of collaborative learning on students' academic performance in chemistry, the same chemistry achievement test (pre-test and post-test) was prepared and given to students in both groups (experimental and control groups). A pre-test was used to find out if there is a statistical difference in students' mean scores before the intervention, while a post-test was used to find out if there is a statistical difference in students' mean scores after intervention. The research instrument adopted by the researcher in this stage was an objective test composed of 10 closed items on the topic of preparation and classification of oxides. The data collected from the chemistry achievement tests were transcribed and analyzed through the use of Microsoft excel 13.

Data analysis methods

Data analysis is defined as the science of examining raw data to conclude (Israel, 2008). Thus, descriptive statistics and an inferential statistics t-test were used to assess the impacts of collaborative learning and traditional lecture teaching methods on students' performance in chemistry (See Table 3). Mean scores, standard deviation, and t-test were also calculated (See Table 1&2). Furthermore, graphs were generated and interpreted (See Figure 1&2).

Validity and reliability of the study

Validity and reliability refer to the instrument to measure what is intended to measure (Golafshani, 2003), while reliability, indicates the extent to which an assessment tool provides consistent and stable results (Taherdoost, 2018). For determining the validity and reliability of research instruments, a test-retest technic was used. This technic allowed us to compare the pre-test and post-test scores from the pilot study. While conducting test-retest, the data obtained through a re-administration of the instrument after two weeks correlated with the data obtained in the pre-test. According to Cho and Kim (2015), the criteria of Cronbach's alpha coefficient of the internal reliability is in four categories: Excellent ($\alpha>0.9$), good ($0.7<\alpha<0.9$), acceptable ($0.6<\alpha<0.7$), Poor ($0.5<\alpha<0.6$), and unacceptable ($\alpha<0.5$). To calculate Cronbach's alpha coefficient, we used the Pearson product-moment correlation (r). $r = \frac{N\sum XY-(\sum X)(\sum Y)}{\sqrt{[N\sum X^2-(\sum X)^2][N\sum Y^2-(\sum Y)^2]}}$ where N is a number of respondents, X is the first administration of test scores (pre-test), and Y is the second administration retest scores (post-test). The Reliability coefficient calculated for this study's instrument was 0.83, which is a good coefficient. This ensured us that the instrument is worthy to collect reliable data. Besides, content validity on chemistry achievement tests on preparation and classification of oxides was checked by teams of experts in chemistry education.

Ethical considerations

This study was funded by the African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS) and ethical approval for this study was granted by ACEITLMS authorities. Before data collection, all participants were given equal chances for participating in the study. Before data collection, participants had to sign a consent form agreeing voluntarily to participate in the study after understanding the purpose of the study. Since some of the participants were students under 16 years old, we asked permission from parents and schools authorities to allow the involvement of students in this study.

Results

Students' performance in the pre-test

To address the research question, a pre-test was given to students in both control and experimental groups. The content covered in a pre-test was about the reparation and classification of oxides. This test was given to students to see their status in the preparation and classification of oxides before the intervention. Figure 1 shows how both control and experimental groups performed the pre-test. The horizontal axis shows test scores in percentage (%), while the vertical axis represents the number of students in both control and experimental groups.

Figure 1 shows that the students' highest score range in the pre-test is between 31 and 40 for both control and experimental groups. Thirty-five and 40 students in the experimental group are found in the range of 31-40 scores. There are only eight students in the control group and 14 students in the experimental group who are found in the 0-10 score range. The maximum score was in the range of 81-90, whereby only one student from the experimental group is identified. When comparing students' performance of the pre-test for both students in the control and experimental group, their marks are very close, and the number of students in both groups is close for each range. This shows that students in the control and experimental group are at the same level of performance of chemistry in general and in the preparation and classification of oxides in particular.

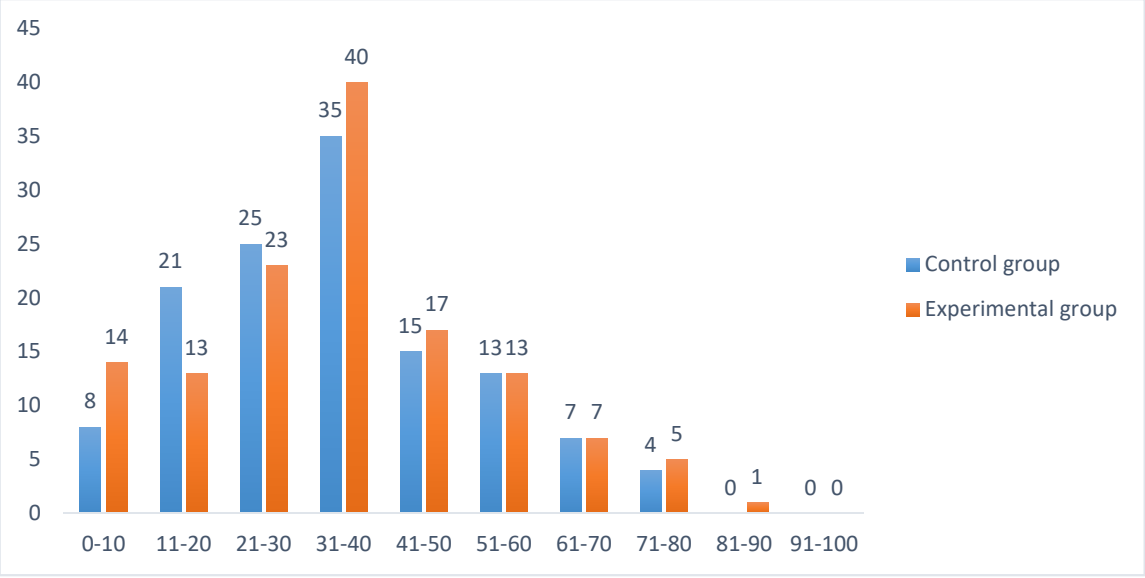

Figure 1 Students' performance of the pre-test in control and experimental group

Referring to the descriptive statistics, Table 1 shows how students in the control and experimental group performed the pre-test. The table shows the mean scores for each group, the standard deviation, the minimum, and maximum scores, and the mean difference.

Table 1 Descriptive statistics of students' results of the pre-test in control and experimental groups

Groups	N	Mean	Std. Dev.	Min	Max	Mean difference
Control	128	35.57	16.77	6.67	76.67	1.27
Experimental	133	36.82	17.87	6.67	83.33	

Table 1 shows that the mean score is 35.57% in the control group and 36.82% in the experimental group. The standard deviation (STD) is 16.77 in the control group, while it is 17.87 in the experimental group. The minimum score is the same in both groups. The maximum score is 76.67% and 83.33% in the control and experimental group respectively. The results analysis showed that students' scores are very close since the mean difference is 1.25.

Students' performance in post-test

After seeing that students are at the same level of understanding, students were taught with two different methods during a period of one month. One group of 128 students in the control group were exposed to the lecture traditional teaching methods, while another group of 133 students in the experimental group taught with collaborative learning methods. After a period of one month of intervention, all students in the control and experimental group were given a post-test. The post-test was given to students to compare their scores in both groups. The comparison was intended to analyze and see whether there is a statistically significant difference between students taught with collaborative learning, and those taught with lecture traditional teaching methods. The students' scores are presented in Figure 2. The horizontal axis represents the score ranges in percentages (%), while the vertical axis shows the number of students in both the control and experimental group.

Figure 2 shows a significant difference in students' performance of the post-test. The students' highest score range in post-test is between 31 and 40 score range in the control group, while the highest score range is 61-70 in the experimental group. There are two students in the control group found in the 0-10 scores range, while none from the experimental group was found in this range. Contrarily, we identified 14 students from the experimental group who had the maximum score in the range of 91-100, while none from the control group was identified in this range. When comparing students' performance of the post-test for both students in the control and experimental group, we found an apparent difference, as shown in Figure 2, since the majority of students (76 out of 128 or 59% students) in the control group scored below or equal to the pass mark (<, =50%). Few students (33 out of 133 or 25% students) in the experimental group, scored below or equal to the pass mark (<, =50%). This shows that students in the experimental group performed better than those in the control group.

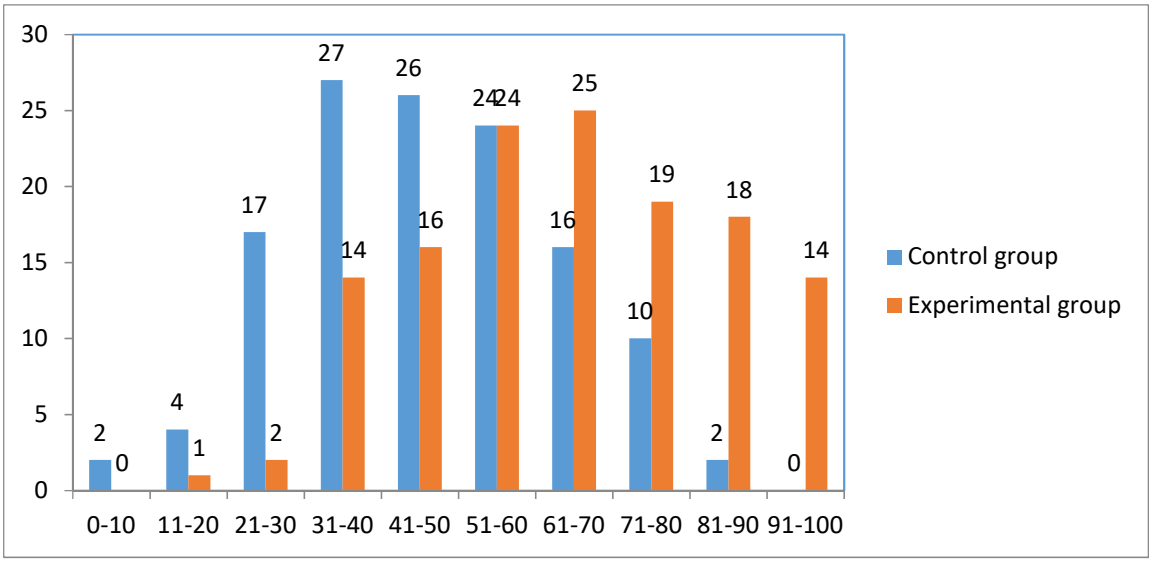

Figure 2: Students' performance of the post-test in control and experimental group

Using the descriptive statistics, Table 2 shows how students in the control and experimental group performed the post-test. The Table shows the mean scores for each group, standard deviation, minimum, and maximum scores, and mean difference.

Table 2 shows that the mean score in the control group is 47.58%, and 65.39% in the experimental group. The Standard deviation TD is 16.82 in the control group, while it is 17.87 in the experimental group. The minimum score is 6.67% in the control group and 16.67% in the experimental group. The maximum score is 83.33% and 100.00% in the control and experimental group respectively. Table 2 shows that students effectively learned through the methods used with an increased mean score in both groups since there is a difference in performance between the two groups.

Although the comparison made between the results from Table 1 and Table 2 show that students in both groups benefitted from the methods used by the chemistry teachers, it is clear that students in the experimental group outperformed their counterparts in the control group with a 17.81% mean difference. In addition, the minimum score kept on being 6.67 % for the pre-test and post-test in control, while it shifted from 6.67 % to 16.67% in the experimental group. The maximum score shifted from 76.67% to 83.33% in the control group, with an increment of 6.66%. In the experimental group, the maximum score shifted from 83.33% to 100% with an increment of 16.67%. The STD (16.82) in the control group is far from the mean (47.58) compared to the experimental group, which means that scores in the control group are also scattered.

While calculating the learning gain (<g>), we found the values which are close and positive. The learning gain was <g>= 0.19 in control group and <g>=0.45 in experimental group. Since the values found are both positive, this means that both students in the control and the experimental group have effectively learned. However, the results show that students in the experimental group learned more effectively since the learning gain in the experimental group is greater than that of the control group.

To find out whether there is a significant statistical difference between students' performance in the control and experimental group, inferential statistics measures were used. We, therefore, used a t-test of two independent samples. Table 3 shows the results obtained.

Table 3 Independent samples t-tests f students' performance between the control and experimental group

Measures	t-stat	df	T-Critical	Sig. (1-tailed)
Before Intervention	-0.58	259	1.65	.28
After Intervention	-8.05	257	1.65	.000***

***T-value significant at p < 0.001

The Table 3 shows that before intervention, the t-test showed [t (259) = -0.58, p = .28; p>.05], indicating that the difference in mean score was not statistically significant. This implies that students' level of performance was the same before the intervention. However, after the intervention, the t-test showed [t (257) = -8.05, p = .000; p<.001] indicating that there is a statistically significant difference in mean scores between the control and experimental group.

Discussion

The fact that the p-value is less than 0.001 of significance level, implies that we are 99.9% confident that the difference found in mean scores did not occur by chance. We, therefore, reject the null hypothesis, in favor of the alternative hypothesis which asserts that students taught under collaborative learning performed better in preparation and classification of oxides than those taught using traditional lecture teaching methods. Many scholars have conducted studies whose findings corroborate the present study's results. For instance, Fakomogbon and Bolaji (2020) found that collaborative learning facilitates learning and improves students' performance. Authors also found that collaborative learning helped learners to share what they acquired which helped students in their learning performance, as a whole group or individually. Similarly, Nkechinyere et al. (2018) confirmed that it is through collaborative learning, students' retention was enhanced and students taught through collaborative learning strategy achieved better than those exposed to lecture-based teaching strategy. Although Abdulwahab (2016) found that there was no significant difference in the achievement of students taught using cooperative instructional strategy and those exposed to traditional lecture method (t=7.26, p>0.05), the author witnessed a statistically significant difference in the student's achievement based on their scoring level when taught using the cooperative instructional strategy (F=4.850, p<0.05) in favor of the low scorers who benefitted the most. Thus, to enhance students' performance, students need to learn actively through collaborative learning-based instructions since once there is no collaboration among students, there will be also poor academic achievements among students (Uwizeyimana et al., 2018).

The students' performance found in the control group for our study, may not have only been influenced by the method used, but the method used itself may have influenced students' performance and motivation. We thus concur with scholars like Adolphus,

Alamina, and Aderonmu (2013) who argued that through collaborative learning, students were not scared with physics content while learning simple harmonic motion. Students got motivated while they were solving cooperatively physics problems. The statistical analysis showed that there was a significant difference between students taught using collaborative learning strategies and those taught with the traditional lecture teaching methods. The authors recommended that teaches should encourage group discussions, group projects, activities, and assignments that promote collaborative learning for students to improve their problem-solving abilities. Similarly, Olanrewaju (2018) found in his study a significant difference in students' achievement of Mathematics learning achievement for those students who learned through collaborative learning techniques compared to their counterparts in the control group ($t= 58.75$; $p<0.05$). In addition, the author found that students' mathematics anxiety in the experimental group was low compared to those control group.

Collaborative learning is not only effective in a conventional classroom, but also for virtual classes in e-learning. For instance, Fakomogbon and Bolaji (2017) also found that there is a significant gain in students' performance in the mobile learning experience, and think-aloud-pair problem-solving skills while a collaborative learning style was employed. The students' abilities and skills were increased in the post-test compared to the pre-test. We, therefore, conclude, as drawn also by Izuegbunam and Abigail (2018) that there is a significant difference between the mean score achievement of students in chemistry taught using collaborative learning, and traditional lecture-based instruction teaching strategies in favor of cooperative learning as the most effective method.

Conclusion

This study investigated the impacts of collaborative learning on learners' academic performance in chemistry in three selected secondary schools of Nyamasheke district. The study employed a quasi-quasi experimental research design that employed a pre-test and a post-test. All through the results from the pre-test [t (259) = -0.58, p = .28; p>.05], indicated that there was no statistically significant difference between the two groups before the intervention, the inferential statistics results from the post-test [t (257) = -8.05, p = .000; p<.001] showed that there is a statistically significant difference in mean scores between the control and experimental group. We, therefore, rejected the null hypothesis, in favor of the alternative hypothesis to confirm that students taught under collaborative learning performed better in preparation and classification of oxides than those taught using traditional lecture teaching methods.

Limitations and recommendations

This study was conducted in three public schools of Nyamasheke district, Western province of Rwanda. The researcher intended to inform the educational stakeholders about the teachers' awareness and what it requires to implement collaborative learning. In addition, the researcher wanted to contribute to the existing literature about the impacts of implementing collaborative learning while teaching and learning chemistry within secondary schools of the Nyamasheke district. However, this study was limited only to the Senior Two secondary school students. Thus, we could not generalize our findings to the whole secondary school students within Nyamasheke district, and to the country as a whole. Thus, this study recommends that there should be further research covering a wide range of the country for more generalization of the findings. While conceiving our study, we did not put our emphasis on observing to

see how teachers practice collaborative learning in classrooms while teaching chemistry. Thus, further study should be conducted investigating how chemistry teachers implement collaborative learning to enhance secondary school students' performance of chemistry.

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Conflict of interest

Authors claim no conflict of interest

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