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Active learning as an approach for teaching respiratory concepts and soft skills in biology lessons

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ABSTRACT

Active learning can promote learners' acquisition of science concepts and soft skills. Secondary school science lessons play a significant role in nurturing students' learning of science concepts and essential soft skills, such as communication, collaboration, critical thinking, creativity, and innovation skills. This study explored grade 11 students' learning of respiratory concepts and soft skills using the mixed-methods research approach. Quantitative data were obtained using an achievement test administered to 104 students, while qualitative data were collected by observing 24 case students during the lessons and focus group interviews conducted after the lessons. The findings show that active-learning strategies contributed to students' learning of respiratory concepts and soft skills. Regarding respiratory concepts, the study revealed that the most misunderstood concepts included the by-products of anaerobic respiration in animals, equations for tissue respiration, and the relative amount of energy yielded in anaerobic respiration in plants and animals. The least understood concepts included stating the by-products of anaerobic respiration in animals, suggesting that students may hold misconceptions about these concepts. Lesson observations showed that students engaged in the lesson mainly through group work/cooperative learning, learning by teaching, and identifying and correcting mistakes. Students' interviews highlighted that active learning was exciting, enabled knowledge sharing, improved higher-order thinking skills, involved all students, and encouraged student collaboration. The study recommends that teachers use various active learning strategies in their lessons to improve students' learning. Furthermore, the study recommends explicit assessment of the soft skills that contribute to students' learning.

Contribution/Originality: This study examined how active learning in biology lessons can promote the acquisition of both content knowledge and soft skills. It enriches our understanding of effective teaching practices by providing practical examples of how teachers can enhance students' mastery of content and soft skills through engaging and skill-focused lessons.

1. INTRODUCTION

Active learning approaches have been reported to enhance learners' conceptual understanding of science, technology, engineering, and/or mathematics concepts (Balta & Awedh, 2017; Freeman et al., 2014; Oanh & Dang, 2025). By engaging students actively in learning, active learning strategies can help overcome the learning difficulties students may present in the classroom. In biology, respiratory concepts are among the concepts that some students find challenging to learn. According to Dam, Ottenhof, Van Boxtel, and Janssen (2019), students face challenges in learning respiration because most respiratory concepts are very abstract, and some students fail to connect the sub-processes of respiration to real-life situations. Respiratory concepts are taught in many biological sciences in the Zambian curriculum from primary to tertiary level (Curriculum Development Centre, 2023). At the secondary school level, for example, students are expected to learn about types of respiration and gaseous exchange. Learning difficulties faced by students have been attributed to inappropriate teacher-centered approaches, which mainly result in rote or surface learning (Ismail, Awang, Pyng, & Abdullah, 2020; Manishimwe, Shivoga, & Nsengimana, 2023; Thaman, Dhillon, Saggar, Gupta, & Kaur, 2013). However, several scholars suggest that using active-learning approaches that engage students in the learning process may reduce the challenges faced when learning science concepts (Aji & Khan, 2019; Fernández-González & Franco-Mariscal, 2021; Mohammed, Alqasa, Abdallah, & Afaneh, 2022; Orak & Demirci, 2018; Saira, Fouzia, & Hafeez, 2021).

Although researchers define active learning depending on their contexts and the focus of their studies, they agree that it consists of teaching-learning approaches that put learners in charge of their learning (Cooper, Downing, & Brownell, 2018; Darby, Lang, & Cavanagh, 2023; Mohammed et al., 2022). Active learning engages the learner behaviorally, cognitively, or socially (Teppo, Soobard, & Rannikmäe, 2021; Windschitl, 2002). Behavioral engagement involves actively using and or creating learning materials. Cognitive engagement involves actively thinking and or constructing new meaning from learning. On the other hand, social engagement involves actively working with others as collaborators and resources for further learning. Freeman et al. (2014) assert that students in active learning engage in activities or discussions during lessons rather than passively listening to their teachers. Cooper et al. (2018) add that active learning strategies include writing brief exercises, working in pairs or groups, debating, role-playing, and engaging in cooperative learning. Other active learning strategies are learning by teaching/presenting, verifying correctness, and identifying mistakes and causes.

Aside from enabling students to learn the core concepts in a subject, science learning should develop students' skills, e.g., critical thinking skills (Muhfahroyin, Rachmadiarti, Mahanal, Zubaidah, & Siagiyanto, 2023; Oanh & Dang, 2025; Velásquez & Quiroga, 2024). Therefore, using active learning may enable students to acquire knowledge in biology, as well as soft skills (Betti, Biderbost, & García Domonte, 2022; Velásquez & Quiroga, 2024). Altinyelken and Hoeksma (2021) assert that active learning is positively associated with the development of skills and competencies (e.g., critical thinking, creativity, and problem-solving) that are relevant to 21st century problems. These skills, including critical thinking, communication, and collaboration, comprise key 21st century skills (Rahmatika et al., 2024; Susilawati, Aznam, Paidi, & Irwanto, 2021).

In line with the demand for soft skills, many African countries, including Zambia, South Africa, Rwanda, and Kenya, have adopted curricula emphasizing soft skills in core subjects (Busaka, Kitta, & Umugiraneza, 2022; Manishimwe et al., 2023). For example, the Zambian secondary school competence-based curriculum advocates using active learning strategies to deliver biology content. Along with the content, teachers should equip learners with relevant competencies or soft skills such as critical thinking, collaboration, communication, and creativity. However, there is a paucity of research investigating the impact of active learning on the learning of science and soft skills, particularly in biology and at the secondary school level. Furthermore, there is a lack of research demonstrating how active learning influences the learning of respiratory concepts and skills, particularly in the African context. Although the Zambian secondary school biology syllabus advocates the use of active learning in classes, little is known about what an active learning classroom looks like in Zambia. Therefore, this study sought to close this knowledge gap by investigating how active learning strategies (such as group work/cooperative learning, learning by teaching, and identifying and correcting mistakes) influence students' learning of respiratory concepts and soft skills at a Zambian secondary school. The study was guided by the question: *What elements of active learning influence students' learning of respiratory concepts and soft skills?*

The findings have practical implications that support the constructivist view of learning through the influence of active learning on students' learning of biology concepts and soft skills. The study demonstrates how secondary school teachers may implement active learning in biology lessons and explicitly assess students on the learning of soft skills. The study demonstrates how active learning strategies can be conducted to facilitate students' learning of content and essential skills in science lessons. The study adds to our understanding of the role that constructivist learning activities have on students' learning. Furthermore, the study illustrates how teachers can monitor students' essential skills. Also, the study bridges the gap in the literature on active learning in biology education in Zambia and beyond. The insights from this study contribute to the global discussion on the role of active learning strategies in enhancing the learning of science and soft skills.

2. EFFECTS OF ACTIVE LEARNING

This study draws from the literature on various forms of active learning in the context of teaching and learning across disciplines and levels. For instance, Day and Bryce (2013) reported that about half of the students enjoyed discussing in class, and about 60% found the class interesting. However, only 45% of students reported being allowed to express their views during these deliberations. Thaman et al. (2013) reported that active learning strategies helped students understand respiratory physiology concepts better and increased their interest and interaction. A study by Artut and Bal (2018) concluded that cooperative learning increased prospective teachers' learning and had a positive effect on them. Furthermore, Balta and Awedh (2017) assert that collaborative learning contributes to students' conceptual understanding of topics and skills such as communication and problem solving. In addition, Fernández-González and Franco-Mariscal (2021) concluded that active learning helped develop students' scientific knowledge through group work. Orak and Demirci (2018) concluded that using active learning made students' learning more effective and enjoyable and increased their self-esteem. These studies demonstrate the benefits of active learning approaches in facilitating students' learning.

Several other studies have also reported on active learning environments. For example, Cooper et al. (2018) investigated the impact of active learning strategies (group work, clicker questions, cold calls, and random calls) on students' anxiety. The study concluded that active learning could either increase or decrease students' anxiety depending on how it was implemented. Additionally, Dag, Şumuer, and Durdu (2019) found that students had positive perceptions and experiences of the active learning model and environment. Aji and Khan (2019) reported an improvement in the performance of students exposed to active learning-enriched courses. A study by Özalemdar (2021) concluded that active learning positively influenced students' environmental attitudes and environmental behavior. However, Betti et al. (2022) concluded that active learning via a flipped classroom did not improve or worsen students' hard and soft skills. Recently, Manishimwe et al. (2023) concluded that the active learning group outperformed the conventional learning group. In summary, these studies illustrate the potential of using active learning strategies to enhance students' learning and academic performance. Results from these studies also appear to be mixed, with some reporting no improvement in learning. Therefore, it may be worthwhile to explore how active learning influences the learning of content and soft skills.

3. THEORETICAL FRAMEWORK

This study was underpinned by the theory of constructivism, a commonly used learning theory in science education research (Almulla, 2023; Larison, 2022; Nyamekye, Asare-Danso, & Ofori, 2025). A central idea of constructivism is that learners construct their knowledge based on prior knowledge about the content being learned through active engagement (Almulla, 2023; Larison, 2022). In constructivist learning, students add new information to preexisting mental frameworks and build upon their prior experiences and worldviews to develop and retain knowledge (Larison, 2022). Constructivist learning can consist of cognitive constructivism (individual cognitive processes), social constructivism (social co-constructing knowledge), or a blend of cognitive and social constructivism (Nyamekye et al., 2025; Teppo et al., 2021). The present study was informed by both cognitive and social constructivist elements.

One component of constructivism is active learning, which consists of strategies that put learners in charge of the learning process through active engagement (Cooper et al., 2018; Mohammed et al., 2022). Hartikainen, Rintala, Pylväs, and Nokelainen (2019) recommended that research that uses active learning must provide explicit descriptions and theoretical justifications for its use. Therefore, in the current study, active learning consisted of group activity (cooperative learning), learning by teaching (making presentations), and identifying and correcting mistakes through which learners engaged in the learning process. Learners were given opportunities to collaboratively construct knowledge about types of respiration and communicate this knowledge to their colleagues, firstly in their groups and later to the whole class. Therefore, learners constructed knowledge through active engagement with the biology concepts individually and in groups. This was seen as vital for learning biology concepts and developing high-order thinking skills.

4. METHODOLOGY

4.1. Research Approach

This study adopted a mixed-methods research approach to explore and provide an in-depth description of the teaching and learning of respiratory concepts and soft skills in two research lessons. The concurrent research design was adopted, whereby qualitative and quantitative data were collected and analyzed simultaneously (Creswell & Creswell, 2018). This approach was used because it allowed: (1) an assessment of students' learning, (2) an evaluation of students' engagement in lessons and its value, and (3) an evaluation of students' views of the research lessons. Using multiple methods to collect data was relevant to this study as it allowed a better and more in-depth understanding of the teaching and learning of respiratory concepts and soft skills.

4.2. Sampling Procedures and Ethical Considerations

The sample comprised two Grade Eleven classes purposively selected at a secondary school in Lusaka Province, Zambia. The school was selected purposively because the teachers were available to participate in all the lesson study stages. The classes were selected so that one class was a low-ability class and the other a high-ability class. The students' sample consisted of 104 students. For an in-depth description, 24 case students were purposively selected from the two classes, ensuring the inclusion of high-, average-, and low-achieving students. Additionally, six biology teachers (three males, three females) who taught biology at the school participated in the planning, teaching, and observing of students during the lesson enactment.

Before data collection, the researcher obtained research permits from the Ministry of Education. Furthermore, a written permit was obtained from the headteacher of the school. Teachers' and students' participation in the study was voluntary. They were assured that the identities of the school, teachers, and students would not be disclosed. Furthermore, consent was obtained from the headteacher for the use of these pictures.

4.3. Teaching and Learning Sessions

The study investigates how active learning influences the learning of respiratory concepts and soft skills during two research lessons. The lesson study team, consisting of six biology teachers, planned to enhance their skills in using active learning in their biology lessons. Two lesson study cycles were conducted as described below:

4.3.1. Research Lesson One

In the first research lesson, the teachers collectively planned a lesson reflecting the respiratory concepts and soft skills students are expected to learn (Curriculum Development Centre, 2023). Two planning sessions were held, each lasting sixty minutes. Teachers reflected and built on the ideas and contributions of other team members regarding the content, methods, and activities to be included in the lesson. The lesson was then taught to a class of grade 11 students by one of the teachers. The other team members observed the lesson and took notes mainly about students' learning and involvement. The lesson lasted about 80 minutes. After the lesson, the team met for sixty minutes to reflect on and discuss their observations.

4.3.2. Research Lesson Two

The second research lesson was an improvement of the first one based on the teachers' observations. Each teacher was allowed to report on the positive and negative aspects of the lesson. Then, the team members discussed how to improve the negative aspects of the first lesson. The improved lesson (research lesson 2) was then taught (for 80 minutes) to another grade 11 class by the same teacher. Again, the other teachers observed the lesson and took notes mainly about students' learning and involvement. After the lesson, the team met again to reflect on and discuss their observations. They suggested minor improvements to research lesson 2, resulting in research lesson 3.

During both lessons, the teacher provided students with opportunities to actively engage in the lessons. The lessons were characterized by students working in small groups and presenting their group work to the class. The teacher also engaged students by asking questions that students had to answer during the lessons.

4.4. Research Instruments

The data were collected using an achievement test, a lesson observation checklist, and a focus group interview (FGI) guide. All instruments were adapted by the first author and validated by three biology education lecturers and the lesson study team.

4.4.1. Achievement Test

The research team developed an achievement test comprising 16 questions about respiratory concepts. The questions were adapted from past examination papers from the Examinations Council of Zambia (ECZ). The test was used to determine students' mastery of respiratory concepts taught in the lessons. The respiratory concepts and learning activities covered in the study are reported in the results section in Table 1.

4.4.2. Lesson Observation Checklist

The observation checklist, consisting of 24 learning activities, was developed after a literature review. The learning activities (indicators of learning) are reported in the results section, Table 2.

4.4.3. Focus Group Interview Guide

The interview guide was adapted from Dudley (2012) and validated by four biology education lecturers. The interview questions probed students' views and experiences of the active learning activities they engaged in. Sample interview questions include: (1) What did you enjoy most about today's lesson? (2) Was there anything you did not enjoy about the lesson? (3) What did you learn in today's lesson? (4) What helped you to learn today? (5) I saw you explaining/presenting to the group/class; were you enjoying that? (6) What aspect of the teaching/learning worked best for you? (7) What could your teacher do to help you learn more?

4.5. Data Collection Procedures

Data were collected in three stages that is, during lesson observation, achievement test, and students' focus group interviews. During lesson observations, teachers used the checklist to indicate the skills they saw the case students demonstrate. They also noted evidence of learning respiratory concepts through field notes. This was triangulated with data from the researchers' field notes and students' focus group interviews. The achievement test was given at the end of each lesson to capture the respiratory concepts that students had learned. After each lesson, two focus group interviews (FGI) were conducted with case students to elicit their views and experiences of the active learning approaches used in the lessons. Each FGI consisted of six students and lasted about 30 minutes. The FGI sessions were video recorded and transcribed verbatim for deeper analysis.

4.6. Data Analysis Procedures

The teachers marked the students' achievement tests based on an agreed-upon marking scheme, while the first author checked the marked scripts. Every correct response was assigned a 'one mark,' and every wrong response a 'zero mark.' Descriptive statistics were computed using SPSS 25 to indicate the proportion of students who responded correctly or wrongly, based on Jammeh, Karegeya, and Ladage (2023).

Therefore, frequencies of *0 to less than 20%* represented *poor conception*, *20 to less than 40%* represented *weak conception*, *40 to less than 60%* represented *moderate conception*, *60 to less than 80%* represented *adequate conception*, and *80 to 100%* represented *strong conception*, as shown in Table 1.

The teaching-learning activities that contributed to students' learning of respiratory concepts and soft skills were determined by ticking against each observed activity/indicator on the observation checklist; a blank indicates the activity was not observed. The total frequency for each activity was obtained by counting and summing all the ticks indicated for both lessons and expressing it as a percentage using the formula below; the results were reported in Table 2.

$$\%\ of\ observation = \frac{\text{n}\ (number\ of\ observations/ticks)}{9\ (number\ of\ observers)} * 100 \qquad (1)$$

The data from students' FGI and lesson analysis were analyzed using thematic analysis (Braun & Clarke, 2019). The first step involved reading and rereading the entire individual transcripts before assigning codes. Recurring ideas were assigned descriptive codes.

This step enabled a holistic understanding of participants' responses (Creswell & Creswell, 2018). Transcripts were read several times while identifying phrases that described learning aspects. To ensure rigour and minimise bias, an independent researcher was consulted about the identified codes and phrases. Next, the codes were refined and grouped into themes with specific descriptive elements. Then, excerpts that represented critical aspects of the theme were identified and used to support the claims.

4.7. Validity, Reliability, and Trustworthiness

As already mentioned, the research instruments were validated by four biology education lecturers and the lesson study team. Additionally, credibility was ensured through prolonged immersion with the data and member checking with the research team members. Transferability was ensured through an in-depth description of the context of the study so that readers can compare it with the settings in their contexts. To ensure dependability and confirmability, an in-depth description of the data collection and analysis procedures was given, and direct quotes were used to support the claims.

5. FINDINGS

This section presents the results of the study on students' learning of respiratory concepts and soft skills in two biology lessons conducted during a lesson study.

5.1. Understanding of Respiratory Concepts

The results on students' understanding of respiratory concepts are presented in Table 1, which shows the proportion of students who answered the items correctly and incorrectly, along with the corresponding level of conception.

Table 1. Students' (n =104) performance in the achievement test.

Item	Task/Respiratory concepts assessed	Response				Level of conception
		Correct		Wrong		
		n	%	n	%	
1.	Identifying the process that releases energy	104	100.0	0	0.0	Strong
2.	Identifying reactants and products of anaerobic respiration in muscle	72	69.2	32	30.8	Adequate
3.	Identifying the type of respiration that yields the highest amount of energy	94	90.4	10	9.6	Strong
4.	Explaining the term tissue respiration	99	95.2	5	4.8	Strong
5.	Writing down the word or chemical equation for tissue respiration.	65	62.5	39	37.5	Adequate
6.	Explaining the term aerobic respiration	93	89.4	11	10.6	Strong
7.	Explaining the term anaerobic respiration	93	89.4	11	10.6	Strong
8.	Identifying the role of oxygen in aerobic respiration	97	93.3	7	6.70	Strong
9.	Identifying the role of oxygen in anaerobic respiration in animals	79	76.0	25	24.0	Adequate
10.	Identifying the role of oxygen in anaerobic respiration in plants	74	71.2	30	28.8	Adequate
11.	Stating the relative amount of energy yielded in aerobic respiration.	86	82.7	18	17.3	Strong
12.	Stating the relative amount of energy yielded in anaerobic respiration in animals.	69	66.3	35	33.7	Adequate
13.	Stating the relative amount of energy yielded in anaerobic respiration in plants.	62	59.6	42	40.4	Moderate
14.	Stating the byproducts of aerobic respiration	78	75.0	26	25.0	Adequate
15.	Stating the byproducts of anaerobic respiration in animals.	59	56.7	45	43.3	Moderate
16.	Stating the byproducts of aerobic respiration in plants.	70	67.3	34	32.7	Adequate

Table 1 shows that students' conceptions of respiratory concepts ranged from moderate to strong. The results indicate that all students (100%) were able to identify respiration as the process that releases energy from the breakdown of glucose (Q1). Furthermore, over 80% of the students were able to: identify the type of respiration that yields the highest amount of energy (Q3), explain the terms tissue respiration (Q4), aerobic respiration (Q6), and anaerobic respiration (Q7), identify the role of oxygen in aerobic respiration (Q8), and state the relative amount of energy yielded in aerobic respiration (Q11). The level of students' conception of these concepts was strong. However, only about half of the students (56.7%) could state the byproducts of anaerobic respiration in animals (Q15), and only 59.6% could state the relative amount of energy yielded in anaerobic respiration in plants (Q13), indicating moderate conception. Furthermore, only about 63% of the students could write the word or chemical equation for tissue respiration (Q5). Students' conception of all the other concepts was adequate.

5.2. Activities that Facilitated Students' Learning

The results in Table 2 show the activities through which students learned respiratory concepts and soft skills. Results indicate that students primarily developed communication skills through class/group discussions (56%) and presentations in class (67%). They demonstrated collaboration skills mainly by taking leadership roles (33%), responding to others in groups or class (33%), and cooperating with others in groups or the class (44%). For creativity and innovation skills, generating ideas in groups or class contributed the most (33%) to the overall creativity and innovation skills score.

Table 2. Activities that facilitated students' (n = 24) learning.

Active teaching-learning activities		Number of times observed		Corresponding soft skills learned
		n	%	
1.	Making a presentation in class	6	67	Communication
2.	Communicating in class/group discussion	5	56	
3.	Giving an oral answer in class	3	33	
4.	Listening attentively to others (including the teacher)	3	33	
5.	Engage in conversation and discussion	0	00	
6.	Responding to others in groups or classes	3	33	Collaboration
7.	Showing responsibility and productivity	2	22	
8.	Showing flexibility when dealing with others	2	22	
9.	Cooperating within the group or class	4	44	
10.	Taking leadership roles	3	33	
11.	Reacting to other pupils' answers or questions	3	33	Critical thinking
12.	Interpreting and analyzing ideas	2	22	
13.	Giving constructive arguments in class or a group	2	22	
14.	Problem-solving	4	44	
15.	Giving reasons for or supporting their idea	3	33	
16.	Generating creative and innovative ideas or solutions	2	22	Creativity and innovation
17.	Working creatively with others	2	22	
18.	Openness and courage to explore other pupils' ideas	3	33	
19.	Refining own or other pupils' ideas	2	22	
20.	Generating ideas in the group or class	3	33	

Some instances where students were seen actively participating in the lessons are illustrated in Figures 1 to 4. Figure 1 shows a student explaining a respiratory concept to the class. Figure 2 shows one instance where students collaboratively constructed a word equation for respiration. Figure 3 shows an instance where students displayed a word equation for respiration. Figure 4 shows a student who attempted to correct a word equation displayed by other students.

Figure 1. A student giving an explanation to the class.

Figure 2. Students constructing the equation for respiration.

Figure 3. Students display the word equation for respiration.

Figure 4. A Student correcting other students.

During the FGIs, students reported that they were given opportunities to collaborate with others within their groups. They further indicated that this kind of learning was not usually provided to them during classes. However, they noted that collaborating with others made the lessons more engaging and facilitated their learning. The themes that emerged from the students' views of the active learning lessons they attended are shown in Table 3.

Table 3. Themes Identified from Students' Focus Group Interviews.

Themes	Description of themes	Sample quotes for each theme
1. Lessons were exciting.	Students indicate a part of the lesson that interested them the most.	I like the part where I come up with an answer, she also comes up with an answer, and then we argue which one is correct. You compare the answers (FGI 2).
2. Lessons enabled students to share ideas.	Students indicate that they learned from other students' contributions.	We got to learn something from other groups, like the others would go there explaining about aerobic respiration, and others would explain about anaerobic respiration. So, as for me, that was very interesting (FGI 2).
3. Lessons improved higher-order thinking skills.	Students indicate engagement in activities that require the use of higher-order thinking.	Ok, we first contribute the points. Then, when you put the points on the table, you choose which one is correct. You choose between those points that you've brought up. That's when you can come up with a correct answer (FGI 1).
4. Lessons involved all learners	Students acknowledged that all of them (students) were involved in the lesson.	The group activity allows everybody to participate; no one can say that they didn't have a group or paper. Those papers [tags] were prepared for each group, which helps everyone to participate… (FGI 1).
5. Lessons enabled learners to assess themselves.	Students identified their own or colleagues' mistakes/Wrong answers.	Because in class, if we have good discussions, we are going to know different people's ideas. And we are going to learn, and if we are wrong, we are going to correct our mistakes (FGI 3).
6. Lessons encouraged student collaboration.	Students indicate that they interacted with each other or learned in groups.	Working as a group, there is a mix of positivity and negativity because some agree while others disagree. Therefore, working in a group is beneficial because I learn things I didn't know, she learns from me, and I learn from her. Yes, she shares opinions, I share mine, and ultimately, we all work towards the same goal. We combine our points to form and present the outcome (FGI 1).
7. Less collaboration among students in regular lessons.	Students indicate that they rarely interact with each other or learn in groups.	What I can say is that it has been a long time since we sat like that, allowing us to come together, come up with one idea, and present the same idea to the whole class. I think it was different from the lesson we did every day (FGI 2).

The excerpts in Table 3 suggest that students felt they benefited significantly from collaborating with others in groups, such as learning what they did not know from their friends' contributions.

6. DISCUSSION

The results of this study suggest that active learning contributed to students' understanding of respiratory concepts and soft skills. However, the findings revealed that the most problematic concepts were related to byproducts of anaerobic respiration in animals, word or chemical equations for tissue respiration, and the relative amount of energy yielded in anaerobic respiration in plants and animals. This indicates that students may still have misconceptions and learning difficulties in these areas. Regarding chemical equations, students faced challenges in writing chemical formulas, especially for compounds like ethanol ($2C_2H_5OH$) and lactic acid ($2C_3H_6O_3$), which were relatively new to most students. Some students also failed to write the chemical formula for glucose ($C_6H_{12}O_6$), despite having encountered it in previous topics such as animal and plant nutrition. Difficulties with chemical symbols may indicate that students have a weak chemistry background.

The findings that active learning enhanced students' understanding of respiratory concepts and soft skills support previous studies that concluded that active learning improved students' understanding of intended concepts or in improvement in students' academic achievement (Aji & Khan, 2019; Betti et al., 2022; Orak & Demirci, 2018). The active learning strategies also facilitated the learning of associated soft skills. These results agree with Yeoh and Otsuka (2019), who assert that students engaged in active learning will continue to achieve the outcomes expected in twenty-first-century learning. The strategies used in the present study contributed to students' learning of respiratory concepts and soft skills in various ways. For instance, all the students in the class were actively engaged in group activities as each was given a paper tag to display with their colleagues. This was also evident in the students' FGIs, as students reflected on their engagement. The study also established that various activities, such as group work, learning by teaching (or peer tutoring), and noticing and correcting mistakes, contributed to students' learning.

The learning-by-teaching strategy was utilized when students presented within their groups or the whole class. For example, when students were presenting their findings (peer tutoring) or defending their answers. This could have increased students' conceptual understanding and academic achievement (Alegre, Moliner, Maroto, & Lorenzo-Valentin, 2019) and communication skills. Besides helping students learn respiratory concepts, communication also helped them become confident learners. The contribution of group activities (cooperative learning) to students' learning of respiratory concepts and soft skills supports previous studies, Muhfahroyin et al. (2023), Rabgay (2018), and Sadi and Çakıroğlu (2011). For example, Rabgay (2018) asserts that cooperative learning improved students' achievement in biology. The finding that students learned from each other during group discussions supports previous studies (Balta & Awedh, 2017; Sadi & Çakıroğlu, 2011). In their groups, students could work together and support each other in learning various respiratory concepts, which may have enhanced their problem-solving skills (Boholano, 2017; Rahmatika et al., 2024). The above discussion shows how various active-learning activities contributed to students' acquisition of concepts in respiration as well as key soft skills.

7. CONCLUSION

In conclusion, the study established the aspects of active learning that contributed to students' learning of respiratory concepts and soft skills. The study used three active learning approaches: group work/cooperative learning, learning by teaching, and identifying and correcting mistakes. The results show that these approaches helped students to learn respiratory concepts and soft skills. The students reported that active learning was exciting, enabled knowledge sharing, improved higher-order thinking skills, involved all students, promoted self-assessment, and encouraged student collaboration. Furthermore, the study has demonstrated how science teachers can explicitly assess students' acquisition of soft skills.

8. RECOMMENDATIONS

The study recommends the use of active learning strategies in science classes to promote content and skills learning. The study also suggests that further research may employ a pre/post-test design to assess the impact of active learning lessons on students' understanding of biology concepts. Furthermore, it recommends that science teachers should evaluate how well students are acquiring the key soft skills that students are expected to learn.

9. LIMITATIONS

This study was limited mainly by not collecting data on students' prior knowledge of the respiratory concepts and soft skills under investigation. However, the findings are relevant in highlighting and demonstrating the planning, teaching, and learning of an active-learning lesson focusing on content and skills learning. Future research may conduct a pre-post intervention study on the whole topic of respiration.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
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