

# RETRIEVAL PRACTICE ACTION RESEARCH TO DEVELOP MIDDLE SCHOOL STUDENTS' KNOWLEDGE OF BIOLOGY TERMINOLOGY

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## ABSTRACT

The researchers, a Secondary school Biology teacher and a language learning specialist, brought their respective fields of competence together to apply the research on retrieval practice, according to which this strategy has a high impact on learning. The students participating in this study were a group of 22 Grade 8 students, predominantly Russian-speakers, attending an English-speaking international school. Their level of English varied from A1 to C1 according to the Common European Framework of Reference (CEFR). The problem identified was the students' lack of confidence in using and understanding Biology terminology effectively. This study aimed to evaluate the effectiveness of retrieval practice as a strategy for English as an Additional Language (EAL) students to improve their competence in this area. The Biology teacher split the unit of work in two; students received a formative test with open books (no retrieval practice) for the vocabulary related to the first half of the unit, and a formative test with closed books (retrieval practice) for the vocabulary related to the second half. Students were then assessed summatively on the full unit. The results for the content which had been formatively tested with open books were compared with the results for the content which had been formatively tested with closed books. The effect measured was small, but confirmed the hypothesis according to which retrieval practice has a positive impact on learning. Metacognition, reflection, and collaboration are all part of the approaches to learning skills modelled to students in this study. Through these skills, which the action research model supports, we not only sought to evaluate the effectiveness of a particular strategy, but also to promote a culture of inquiry and self-directed learning. It offers practical insights for educators seeking to enhance their pedagogical practices and supports students in mastering subject-specific terminology in a second language.

**Keywords:** *action research, language pedagogy, retrieval practice, Middle School, vocabulary instruction, technology.*

## Introduction

Stepping away from the routine of surviving through the demands of teaching, there is one thing passionate educators have in common: they want to have an impact. In fact, according to John Hattie, teachers are more likely to have an impact on learning if they are passionate about helping their students learn (Hattie, 2012). They draw intrinsic motivation from knowing that what they are doing has a purpose and makes a difference for their students' learning (Phelps & Benson, 2012). However, a lack of expertise in meeting the needs of particular groups of students may be a hindrance to the impact even passionate teachers intend to have. Subject teachers teaching students speaking English as an additional language (EAL) face particular challenges, especially when they are not trained language teachers and are concerned with delivering a prescribed curriculum, as is the case in our study. Secondary school teachers frequently feel ill-prepared to meet the needs of EAL students (Rubinstein-Avila & Lee, 2014). Yet research on supporting EAL students in learning content is readily accessible, for instance research according to which explicit vocabulary instruction has a positive impact on EAL students' learning (Oxley & de Cat, 2021). However, good teaching is characterized by thoughtful decision-making and the strategic application of various elements from various techniques to enhance and support student learning, rather than being exclusively linked to one approach (Creemers, 2013). Also, subject teachers may be reluctant to adopt approaches which they might feel detract from their purpose of teaching their subject content. Finally, for teachers to see the value of research findings, they need to see research as relevant to their educational environments. To do so, "learning how to do research through action research projects is amongst the best ways of promoting [...] openness to published research" (Waks, 2020).

The objective of this paper is to evaluate the effectiveness of a learning strategy known to be impactful, retrieval practice, through a participatory action research in the context of a Grade 8 class in an international school in Latvia. Participatory action research ticks the boxes of what John Hattie identified as factors having a high impact on learning, with teachers reflecting on their own practices in their own classroom (Hattie, 2023). Through action research, the Grade 8 Biology teacher and the author of this paper, the Head of Languages, collaborated to apply evidence-based research, monitor the teacher's impact on students' learning and to adjust her approach accordingly, which allowed her to seek to improve her own teaching through student feedback and analysis of results. Students were also involved in the process, thereby developing their metacognition. The class' heterogeneity in English language competence, and the students' observed challenges in using and comprehending complex language in biology, served as the impetus for the research. We sought to experimentally evaluate the idea that retrieval practice could enhance students' understanding of subject-specific terminology by putting it into practice and comparing the outcome of learning subject content with and without retrieval practice. This strategy aimed to contribute to the larger body of educational research on the effectiveness of retrieval practice in a variety of language and cultural contexts, in addition to improving pedagogical strategies for teaching EAL students subject-specific vocabulary.

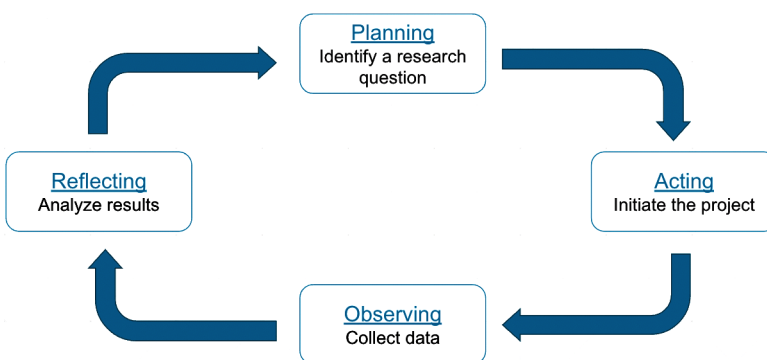
## Literature review

### Action research

Action research in educational settings has been linked to teachers' professional efficacy, empowering both students and teachers in their perception as active change agents as opposed to mere observers (Seider & Lemma, 2004). Teachers become active participants in their professional development and focus on issues specific to their particular audience and context through the 4 stages of action research. As seen in figure 1 (Esparza, Lynch-Arroyo, & Olimpo, 2022), the first step relates to the identification of a particular problem and planning the intervention to tackle it; in the second step, the intervention is carried out and data collected to be evaluated in the third step; finally, in the fourth step, the successes and shortcomings of the chosen approach are reflected upon (Carr & Kemmis, 2005).

In addition to helping educators and students grow professionally, participatory action research (PAR) also assists in creating a cooperative environment that all involved gain from (Sokhanvar & Salehi, 2019). Additionally, McIntyre (2008) defines PAR as an alliance-building initiative that enables researchers and instructors to co-create knowledge by fostering a "self-and critical-awareness that leads to individual, collective, and/or social change" (McIntyre, 2008). Since researchers outside of the classroom setting are "strangers" to practise and gather data for their own objectives, their findings may be far removed from those stemming from practitioners' self-reflection (Waks, 2020). This gap between research and practice in the subject widens even further when the research is published and recognized as authoritative knowledge. It is challenging for practising instructors to comprehend and use the knowledge gleaned from research because of this gap. Educational research needs to fulfil specific requirements in order to support good teaching practices. It is imperative that educators identify with the chosen research materials, perceive the research settings and treatments as applicable to their own classroom environments, and derive meaningful insights from the research process.

### Cycle of Action Research



(Esparza, D., Lynch-Arroyo, R. L., & Olimpo, J. T., 2022)

**Figure 1** Action research steps [graph used with permission from the authors]

However, the implementation of action research in high school classrooms depends on a number of factors, such as support from the administration, which can be in the form of time provided to research literature and plan interventions, as well as promoting “cooperation and collaboration among colleagues and substantive opportunities for professional reflection” (Seider & Lemma, 2004). Another potential hurdle is student resistance to action research, as identified by Esparza, Lynch-Arroyo, and Olimpo (2022). This is another reason why participatory action research was chosen, as it becomes a platform for learning as well as a source of research, thus giving a purpose for participation (Cooper, Shephardson, & Harber, 2002).

## Retrieval practice

Retrieval practice is a learning technique aiming to improve learning and recall by having learners retrieve previously taught material from long-term memory (Agarwal, Nunes, & Blunt, 2021). Learning across a range of ages, content areas, and media was consistently increased by retrieval practice, according to Agarwal, Nunes, & Blunt’s (2021) systematic review of practical studies conducted in classrooms and schools. The review examined 37 studies with  $n = 5374$ , 50 trials, and 49 total effect sizes. Of the studies that were reviewed, the majority (57%) had medium or large effect sizes. The review also revealed that because there are so many variables, classrooms are difficult places to conduct experiments. The evaluation concentrated on data from studies conducted solely in classroom settings and highlighted a number of issues that require further investigation in the future, including the ideal frequency of retrieval practice and whether or not it is beneficial for all topics and age groups. One aspect also identified was that the majority of studies were conducted in WEIRD countries (Western, Educated, Industrialised, Rich, Democratic), with only “3 out of 50 experiments [...] conducted outside the USA and Western Europe” (Agarwal, Nunes, & Blunt, 2021).

A different review of applied research on retrieval practice in educational settings led by Moreira and colleagues brought up a number of issues that still needed to be resolved, including whether or not retrieval practice is enhanced by corrective feedback and whether some test kinds are more (or less) useful than others in educational contexts. Twenty-three articles that satisfied the inclusion criteria were included in the review (Moreira et al., 2019).

## Methodology

### Context and participants

The action research was led in an international secondary school, where the language of instruction is English, but set in Latvia, a non-English speaking country. The participating students were 22 Grade 8 (13 to 15 year olds) students. There was an equal number of male and female students. Nineteen of the students were native Russian speakers, two were native Latvian speakers, one was an Ukrainian native speaker but also a Russian-speaker. All the students were non-native English speakers, or EAL learners, of

varying levels of competence in English. The school uses the Common European Framework of Reference (CEFR) to identify the level of the students in English. According to the CEFR, A1 is the lowest level of competence, meaning an ability to understand and communicate in basic everyday interactions, but not yet showing a Cognitive Academic Level of Proficiency (CALP) allowing them to interact with complex academic content (Cummins, 2013). C1 is the highest level of the framework, indicating an ability to comprehend and produce language in an academic setting in accordance with their age group (Council of Europe, 2014). Within the group, the majority of students were at A2 to B2 level, with a few at the lowest (A1) and highest (C1) level (see table 1).

**Table 1** Sample group’s level of English according to the CEFR

CEFR level	Frequency	Percent	Valid Percent	Cumulative Percent
A1	2	9.091	9.091	9.091
A2	6	27.273	27.273	36.364
B1	7	31.818	31.818	68.182
B2	4	18.182	18.182	86.364
C1	3	13.636	13.636	100.000
Missing	0	0.000		
Total	22	100.000		

As part of their middle school programme, the Grade 8 students follow the Cambridge International Education Combined Science curriculum (code 0653), which includes a Biology component (Cambridge International Education, 2023). The curriculum is split into different chunks of learning, or “units”, which are taught over the course of around 4 weeks each, and which include prescribed learning outcomes assessed in the Grade 10 external examination. The unit taught as part of this study was Animal Nutrition, with the first half of the unit focusing on names of the processes and tooth structure and the second half on alimentary canal structure. The course is not designed with EAL students in mind, so teachers have to be responsive to the needs of their students through implementing recommended strategies, such as pre-teaching vocabulary, scaffolding learning, translanguaging etc.

## Design

The following research question informed the study:

### Does retrieval practice help to develop Grade 8 students’ ability to use and understand Biology terminology effectively?

The inquiry method used was action research, described by Koshy as a productive inquiry, in which the researcher plans, executes, assesses, refines, and gains knowledge about certain issues through experience. The process of learning never stops for the researcher, who also passes on freshly acquired knowledge to others who could find

use for it (Koshy, 2010). As such, this is a method of inquiry fitting the particular needs of the teacher, presented with the contextual issue of having a heterogeneous language competence group to which she had to teach a prescribed curriculum, without being a trained language teacher. The teacher was aware of the difficulty many of her students had in accessing the curriculum, and came to the researcher, the Head of Languages at the school, for support. According to Agarwal, Nunes, and Blunt's systematic review of applied research in schools and classrooms, retrieval practice resulted in an improvement in learning in "nearly all conditions in schools and classrooms" (Agarwal, Nunes, & Blunt, 2021). Therefore, it was decided to focus on this particular strategy to identify whether students' use and understanding of Biology terminology could improve.

Three different online platforms were used as tools to gather data and generate formative quizzes. An Outlook online form, and the teacher online quiz creator Kahoot were used to create anonymous online self-reflection surveys to gather data on students' perception of learning. Retrieval practice was implemented using Quizlet, a web-based software, as well as a mobile device application, which allows users to create their own sets of terminology or other content to memorise through retrieval practice.

### Data collection

Quantitative data was collected through both surveys and test results. The teacher and the researcher first designed an online self-reflection survey to evaluate how students currently perceived their ability in understanding and using subject-specific terminology. The anonymous survey was conducted with the students, asking them to rate themselves on a 5-point likert scale, in answer to four prompts, purposely written in very simple English to ensure even A1 students could understand. The same survey was given again at the end of the experiment, prior to the findings on retrieval practice being shared with the students.

The data generated by the survey confirmed the students lacked confidence overall, in particular while producing language, using Biology terms both in speaking and writing.

A list of key terms was created by the teacher on the online formative tool Quizlet. The application then generates a variety of retrieval practice online activities, including quizzes with a choice of written answers, multiple-choice questions, right or wrong answers, which can either be self-marked online, or printed as a paper quiz. This tool was used to create retrieval practice activities for the students. The independent variable of the study was the formative testing throughout the learning phase. The unit was split in two parts: the first part was formatively assessed through quizzes at the beginning of every lesson the week after the content was taught, with students not allowed access to their books. This meant that students were activating retrieval practice. The second part of the unit was formatively assessed through quizzes as well, this time with open books, hence putting students in a situation where they did not have to activate retrieval practice. The teacher was cautious to ensure that both parts of the unit were of the same level of difficulty.

At the end of the unit, students sat a final summative test, made up of a mix of different types of questions (multiple-choice, labelling and open questions) targeting both parts of the unit. To be noted is that 2 students missed the end of unit test, hence bringing the total number of students to 20. Two versions of the test (test 1 and test 2) were created to avoid students cheating on the student sitting next to them during the test, thus increasing the validity of the results. The students' results were entered in a spreadsheet, with a clear indication of which question matched which part of the unit, to be able to relate results to whether students had used retrieval practice throughout the learning phase or not.

## Results

### Test results

We compared students' use and understanding of terminology for the content formatively quizzed with open books (no retrieval practice) with the content formatively quizzed with closed books (retrieval practice). The closed-book conditions yielded a 60% accuracy rate in correct answers, while the open-book conditions resulted in a 51% accuracy rate in correct answers. Using Jasp, Jeffrey's Amazing Statistics Program (JASP), an open-source software, for the analysis of students' answers to each of the summative test questions, we generated a more detailed statistical analysis.

### Shapiro-Wilk Test

Validating the assumption of normalcy is a crucial consideration for the analyst when performing statistical analysis utilizing parametric methods (Yap & Sim, 2011). To assess the normality of the data distribution, the Shapiro-Wilk test was employed. The test examined whether the data followed a normal distribution, with a p-value above 0.05 indicating normality. In this study, the p-value exceeded 0.05, suggesting that the data was normally distributed (see table 2). Normal distribution implies that the data is equally spread on both sides of the mean score.

**Table 2** Descriptive statistics

	closed	open	overall
Valid	20	20	20
Missing	0	0	0
Mean	0.600	0.507	0.554
Std. Deviation	0.267	0.342	0.280
Shapiro-Wilk	0.907	0.906	0.955
P-value of Shapiro-Wilk	0.056	0.054	0.447
Minimum	0.000	0.000	0.000
Maximum	1.000	1.000	1.000

## Effect Size

### Effect size (Cohen's d)

The size of the observed difference between closed book and open-book settings was determined using Cohen's d. According to Cohen (1988), the effect magnitude was found to be small to medium (see table 3).

### Paired Samples T-Test

A paired samples T-test (see table 3) was used to assess the statistical significance of the observed differences between closed-book and open-book circumstances given the normal distribution. The purpose of this one-tailed test was to ascertain whether, as predicted, performance under one condition was significantly better than the other.

**Table 3** Paired samples T-Test and Cohen's d

Measure 1	Measure 2	t	df	p	Cohen's d	95% CI for Cohen's d	
						Lower	Upper
closed	– open	1.667	19	0.056	0.373	–0.013	∞

Note. For all tests, the alternative hypothesis specifies that closed is greater than open.

Note. Student's t-test.

## Survey results

The surveys conducted at the beginning and at the end of the experiment showed an increase in students' participation, as well as an increase in their confidence. In the first survey, 10 students out of the 22 did not respond, even though all students attended the lesson when the form was shared, due to a technical issue, as many students had difficulty accessing the Microsoft Outlook form. In the second survey, carried out using Kahoot, all students responded. In the pre-experiment survey, out of the 10 students who responded, only 8% felt they understood the teacher's instructions all the time, versus 27% post experiment (see tables 4 and 5). The written instructions comprehension also showed a jump in the level of confidence (see tables 6 and 7).

**Table 4** Frequencies for "I understand the teacher's instructions when she talks" pre experiment

I understand the teacher's instructions when she talks pre experiment	Frequency	Percent	Valid Percent	Cumulative Percent
All the time	1	4.545	8.333	8.333
Most of the time	10	45.455	83.333	91.667
Sometimes	1	4.545	8.333	100.000
Missing	10	45.455		
Total	22	100.000		



**Table 5** Frequencies for “I understand the teacher’s instructions when she talks” post-experiment

<b>I understand the teacher's instructions when she talks post experiment</b>	<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
All the time	6	27.273	27.273	27.273
Almost never	1	4.545	4.545	31.818
Most of the time	11	50.000	50.000	81.818
Sometimes	4	18.182	18.182	100.000
Missing	0	0.000		
Total	22	100.000		

**Table 6** Frequencies for “I understand the teacher’s written instructions” pre experiment

<b>I understand the teacher's written instructions pre experiment</b>	<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
All the time	1	4.545	8.333	8.333
Most of the time	10	45.455	83.333	91.667
Sometimes	1	4.545	8.333	100.000
Missing	10	45.455		
Total	22	100.000		

**Table 7** Frequencies for “I understand the teacher’s written instructions” post-experiment

<b>I understand the teacher's written instructions post experiment</b>	<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
All the time	7	31.818	31.818	31.818
Most of the time	12	54.545	54.545	86.364
Sometimes	3	13.636	13.636	100.000
Missing	0	0.000		
Total	22	100.000		

Regarding production of language, pre-experiment, 42% of students felt they were confident all the time and most of the time using Biology terms while speaking. Post experiment, 54% students felt they were confident all the time and most of the time using Biology terms while speaking (see tables 8 and 9). While using Biology terms in writing, 58% of students felt they were confident all the time or most of the time pre experiment. Post experiment, 72% of students reported feeling confident for the same (see tables 10 and 11).

**Table 8** Frequencies for “I can use Biology terms (words) when I speak in English” pre experiment

I can use Biology terms (words) when I speak in English pre experiment	Frequency	Percent	Valid Percent	Cumulative Percent
All the time				
Most of the time	3	13.636	25.000	25.000
Sometimes	2	9.091	16.667	41.667
Missing	7	31.818	58.333	100.000
Total	10	45.455		
	22	100.000		

**Table 9** Frequencies for “I can use Biology terms (words) when I speak in English” post experiment

I can use Biology terms (words) when I speak in English post experiment	Frequency	Percent	Valid Percent	Cumulative Percent
All the time	3	13.636	13.636	13.636
Almost never	1	4.545	4.545	18.182
Most of the time	9	40.909	40.909	59.091
Sometimes	9	40.909	40.909	100.000
Missing	0	0.000		
Total	22	100.000		

**Table 10** Frequencies for “I can use Biology terms (words) when I write in English” pre experiment

I can use Biology terms (words) when I write in English pre experiment	Frequency	Percent	Valid Percent	Cumulative Percent
All the time	3	13.636	25.000	25.000
Most of the time	4	18.182	33.333	58.333
Sometimes	5	22.727	41.667	100.000
Missing	10	45.455		
Total	22	100.000		

**Table 11** Frequencies for “I can use Biology terms (words) when I write in English” post experiment

I can use Biology terms (words) when I write in English post experiment	Frequency	Percent	Valid Percent	Cumulative Percent
All the time	2	9.091	9.091	9.091
Almost never	14	63.636	63.636	72.727
Most of the time	4	18.182	18.182	90.909
Sometimes	2	9.091	9.091	100.000
Missing	0	0.000		
Total	22	100.000		

## Discussion

In line with the literature on retrieval practice (Agarwal, Nunes, & Blunt, 2021; Yiğit, Kiyici, & Çetinkaya, 2014; Levlin et al., 2022), this study confirms findings according to which retrieval practice has a positive effect on learning. It addresses the challenge identified by Agarwal, Nunes and Blunt in implementing research in a classroom setting. It also contributes to research stemming from non-WEIRD countries, as this study was implemented in the Eastern European region, with predominantly Russian and Latvian native speakers. However, the effect size remains small, and the sample size represents a limitation to the findings of the study. Further avenues for discussion may be considered, such as applying the research in a different educational setting, for example public schools. Broadening the scope of research by targeting bigger groups of more diverse students from a variety of linguistic backgrounds could enhance the findings of the study. It would also be valuable to observe the long-term effect of retrieval practice by applying this research throughout a longer period of time to determine whether retrieval practice leads to sustained improvement in knowledge and application. Further research could also explore the relationship between retrieval practice and student motivation and engagement.

## Conclusion

The effect size showed that using retrieval practice had an impact on performance in this particular classroom setting. This was somewhat supported by the increased level of confidence shown by the survey answers, although the difference in the number of students responding to the survey pre and post experiment constitutes a limitation to this finding. This also highlights the challenges of conducting action research in the classroom. However, the results are encouraging, in that the participation of students and their explicit reflection on their confidence showed that more should be done to include

learners in solving problems faced by teachers in meeting the particular needs of their students. There are implications for teachers' professional development, as conducting action research implies a rigorous approach to identifying a specific problem, discussing solutions and data collecting. Further considerations also need to be given to the potential for collaboration between subject teachers and educators with specific areas of expertise, in this case language learning.

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