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Enhancing Students' Learning Retention Through the Use of Recycled Flashcards as an Eco-Friendly Study Tool

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Abstract: The study aims to demonstrate that recycled flashcards offer a statistically significant improvement in students' retention and understanding while concurrently fostering environmental responsibility by promoting sustainable practices. The expected outcomes suggest this approach is a practical, low-cost, and innovative strategy to enhance academic performance and contribute to the development of holistic, eco-friendly teaching methods aligned with modern educational mandates. General Chemistry is a foundational STEM course universally recognized for its difficulty, largely due to the subject's reliance on abstract, non-visual concepts and extensive details. This challenge often results in poor long-term learning retention, affecting students' subsequent academic performance and confidence. Traditional study aids, while effective for immediate recall, frequently generate additional waste, conflicting with contemporary pushes for sustainable educational practices. This action research, entitled "Enhancing Students' Learning Retention Through the Use of Recycled Flashcards As An Eco-Friendly Study Tool," addresses this dual challenge by investigating the efficacy of utilizing flashcards created from upcycled materials.

Keywords: *Recycled Flashcards, Learning Retention, Study Tool.*

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I. INTRODUCTION

One of the most important foundational courses in scientific education is general chemistry, which serves as a basis for students who want to engage in STEM fields (science, technology, engineering, or math). It includes fundamental concepts at the core of advanced chemistry and related fields, such as monitoring reactions, the construction of atoms, information about acids, heat changes in processes, and how chemicals interact. Even though general chemistry is very important, people typically view it as a difficult subject since it deals with concepts that are invisible, primarily relies on numerical requirements, and has a ton of details that are difficult to understand and retain. Most learners just cram equations or concepts quickly before tests yet can't hold onto these ideas over time - so using them later becomes tough. Learning sticks less these days, which messes up how kids do in school skills plus belief in the topic.

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Accordingly, Kingsepp (2020) tested students' retention of what they learned in a basic chemistry lesson and discovered that just 25% to 50% of them did so. Additionally, studies revealed that students who persisted in their studies performed better in class, demonstrating the clear correlation between achievement and remaining on course. Aside from that, experts observed that the most challenging, yet interesting, sections were those that dealt with stoichiometry, chemical equilibrium, acids and bases, or energy changes. The findings suggest that effective teaching strategies combined with innovative study techniques are crucial for developing long-lasting chemical concepts. If they don't stick, learners can't link what they knew before with fresh topics, so progress slows, affecting how well they do over time do well in advanced classes.

Teachers have recently realized how important it is to use practical approaches to address both lack of interest and poor attention. One of these strategies, the use of flashcards, has gained popularity because it improves memory by evaluating oneself, repeating information, or monitoring progress, essential concepts that form the basis of students' learning. By assessing students' knowledge rather than having them review their notes, flashcards encourage them to study more effectively, strengthening their brain connections and increasing their odds of recalling information in the future. Even while they are effective, traditional flashcards typically require new materials like cardboard or sticky notes, which might result in more waste and ignore the growing trend of eco-friendly education.

This problem led to a shift toward more environmentally friendly classrooms that relieve basic supplies and emphasize nature-based instruction. As learning settings change globally, schools are gradually altering their teaching methods. Scientists are currently investigating whether feeling more in tune with nature leads to better thinking. According to Eco-Friendly Learning: Sustainable Practices in the Classroom (2023), school assignments that incorporate green initiatives, such as repurposing old objects, reducing waste, and coming up with new applications for what is available, might inspire genuine care for the environment and more intelligent daily behaviors. Teachers can promote cerebral growth while emotions and values develop concurrently by modeling sustainable practices during regular classroom instruction. This full-picture way helps learners to see themselves not just as students, yet part of building something that lasts.

Sticking to these goals - learning plus being green - recycled flashcards give a new shot at recalling chemistry basics easier. Old papers or cardboard pieces work just fine when turned into reusable study cards various reusable stuff, turning something that'd just be trash into useful resources learning aids. This method supports eco-friendly practices while keeping mental skills sharp advantages linked to using flashcards for studying. Also, making the students help boost memory using old flashcards helps learners get involved in fun ways while studying, which strengthens learning ideas using pictures along with hands-on activities. Mixing surroundings into learning helps to grow step by step, waking up to learning fits what the Department of Education pushes for pushing for eco-friendly, student-focused methods which also build thinking skills considering environmental duty.

Therefore, this action research entitled "Enhancing Students' Learning Retention through the Use of Recycled Flashcards as an Eco-Friendly Study Tool" seeks to explore how the use of recycled flashcards can improve students' retention and understanding of essential chemistry concepts while simultaneously promoting sustainability and environmental consciousness. By addressing both educational and ecological objectives, the study aims to provide a practical, low-cost, and effective strategy for improving classroom learning. Furthermore, it aspires to contribute to the development of innovative and sustainable teaching methods that not only enhance students' academic performance but also shape their values and behaviors toward building a more responsible, mindful, and sustainable society.

II. OBJECTIVES

This study entitled "Enhancing Students' Learning Retention through the Use of Recycled Flashcards as an Eco-Friendly Study Tool" aims to determine the effectiveness of using recycled flashcards as an eco-friendly study tool in enhancing students' learning outcomes and promote environmental awareness. Specifically, this study seeks to answer the following:

- Identify the physical qualities of the recycled flashcards in terms of:

✓ Durability
✓ Size
✓ Readability

- Evaluate the effectiveness of using recycled flashcards as a learning tool.
- Determine the students' experiences in using recycled flashcards as an eco-friendly study tool?

III. MATERIALS AND METHODS

➢ *Research Design*

Experimental Research Design was employed in this study since it is an effective approach for measuring the impact of an intervention on a single group of participants. Experimental research is a scientific method that helps prove the relationship between dependent and independent variables. This type of research is used to establish a cause-and-effect relationship between the variables and to test hypotheses (Sreekumar, 2025). This design allows the researcher to assess the effectiveness of using recycled flashcards as an eco-friendly tool in enhancing students' learning retention by comparing their performance before and after the implementation of the intervention. It provides a systematic method to determine whether a significant improvement in learning outcomes occurred because of the intervention and aims to improve teaching and learning processes through reflective and evidence-based interventions.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25dec456

In addition, the study utilized a mixed-method design, which combines both quantitative and qualitative approaches. The quantitative aspect involves examining students' test score results to assess the increase in their learning retention. Meanwhile, the qualitative part is gathering participants' feedback and insights through interviews or open-ended questions to better understand their experiences and impressions of utilizing recycled flashcards. The mixed-method approach allows the researcher to verify statistical findings with descriptive data, gaining greater insights into the intervention's effectiveness and applicability.

➢ *Subjects of the Study*

The participants of this study consist of 26 first-year students from BS Sanitary Engineering 1101 enrolled at Batangas State University in the Academic Year 2025-2026 who's currently taking their Chemistry for Engineers 101. These students were chosen through convenience sampling because they were accessible to the researchers and represented the typical population of learners who could benefit from alternative and sustainable study tools. This study was conducted at Batangas State University, Alangilan Campus.

➢ *Data Gathering Instrument*

Data for the study was primarily collected using a questionnaire created by the researcher.

- *Questionnaire*. It was administered to respondents through Google Form and was divided into two sections: Part I focused on evaluating the physical attributes of the recycled flashcards, Part II presents the students' experiences in using recycled flashcards as an eco-friendly study tool.

- *Scoring of Responses*. The four-point scale was used to score responses from parts I, and II. The owing scale continuum was used to describe students' evaluation in the physical attributes of the recycled flashcards and measure their experiences in using the study tool.

Table 1 Likert Scale for Assessing Durability, Size, and Readability

Weight (w)	Scale Range	Adjectival Rating
4	3.50 – 4.00	Highly Durable/ Highly Suitable/ Highly Readable
3	2.50 – 3.49	Durable/Suitable/ Readable
2	1.50 – 2.49	Slightly Durable/Unsuitable/ Difficult to Read
1	1.00 – 1.49	Not Durable/ Highly Unsuitable/ Unreadable

➢ *Data Gathering Procedure*

This study employed experimental research design, integrating both quantitative and qualitative data to provide a comprehensive understanding of the impact of recycled flashcards on student learning retention. Specifically, the quantitative component utilized a quasi-experimental approach through one-group survey questionnaires while qualitative methods (surveys and interviews) were used to gather in-depth insights into student feedback. The research process began with a review of existing studies related to recycled learning materials and retention strategies. The information gathered from the literature helped the researchers design the survey questionnaire suited to the study's objectives. Once the instruments were prepared, they were reviewed and refined to ensure that the questions were clear, relevant, and consistent with the research focus.

After data collection, all responses were compiled and checked for completeness and accuracy. Quantitative results from the survey questionnaire were statistically analyzed to determine measurable progress, while qualitative responses were examined to identify common ideas and themes. This combination of data provided a thorough understanding of the effectiveness and practicality of using recycled flashcards as a sustainable learning tool.

IV. RESULTS AND DISCUSSION

A. Physical Qualities of the Recycled Flashcards

➢ *Durability*

Table 2 below shows the physical quality of the recycled flashcards in terms of their durability.

Table 2 Respondents' Assessment on the Durability of the Flashcards

Rating	Frequency (f)	Weight (w)	f x m	Percent
Highly Durable	15	4	60	57.69%
Durable	8	3	24	30.77%
Slightly Durable	2	2	4	7.69%
Not Durable	1	1	1	3.85%
Total	26		MW =3.42	100%

Table 2 reveals that the recycled flashcards received the highest frequency rating of "Highly Durable" with 15 out of 26 respondents and product of the frequency and the weight of 60. This shows that 57.69% of the participants believe the

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product has excellent durability. The second highest frequency rating was "Durable" with 8 respondents (30.77%). Small numbers rated the flashcard as "Slightly Durable" with 2 respondents (7.69%), and "Not Durable" with 1 respondent (3.85%). The results show that the recycled flashcards are perceived as highly durable, proving that the materials used despite being recycled are sturdy enough for repeated handling.

Similarly, this aligns with what Pass, J (2025) emphasizes that durable materials prevent wear and tears, ensuring that the visual quality and readability of flashcards remain intact over time. Overall, durable flashcards promote sustained use and more effective learning.

- *Size*

Table 3 below shows the physical quality of the recycled flashcards in terms of their size.

Table 3 Respondents' Assessment on the Size of the Flashcards

Rating	Frequency (f)	Weight (w)	f x m	Percent
Highly Suitable	18	4	72	69.23%
Suitable	7	3	21	26.92%
Unsuitable	1	2	2	3.85%
Highly Unsuitable	0	1	0	0%
Total	26		MW = 3.65	100%

Table 3 indicates that the recycled flashcards received the highest frequency rating of "Highly Suitable" with 18 respondents–representing 69.23% indicating strong approval of the product's size, resulting in a computed product of frequency and weight of 72. The next highest frequency rating was "Suitable", chosen by 7 respondents (26.92%). Only 1 respondent (3.85%) rated the flashcards as "Unsuitable", while no respondents selected "Highly Unsuitable". These results imply that most of the respondents view the size of the recycled flashcards as highly suitable, appropriate, and convenient for handling and study purposes.

This result aligns with the studies of Zakian et al. (2022), that states that appropriately sized cards—large enough to display clear text and images—help reduce visual strain and improve attention.

Similarly, Admin (2025) notes that flashcards should be sized based on learners' needs to ensure that information is easily visible and processed quickly. Overall, proper flashcard size enhances clarity, engagement, and learning efficiency.

- *Readability*

Table 4 below shows the physical quality of the recycled flashcards in terms of their readability.

Table 4 Respondents' Assessment on the Readability of the Flashcards

Rating	Frequency (f)	Weight (w)	f x m	Percent
Highly Readable	14	4	56	53.85%
Readable	10	3	30	38.46%
Difficult to Read	2	2	4	7.69%
Unreadable	0	1	0	0%
Total	26		MW = 3.46	100%

Table 4 shows that the recycled flashcards were most highly rated as "Highly Readable" with 14 respondents, represents 53.85% reflects that most of the users find the information easy to read and understand and resulting in a product of frequency and weight of 56. Following this, 10 respondents (38.46%) rated the flashcards as "Readable". While only 2 respondents (7.69%) considered the flashcards "Difficult to Read", and none of the respondents rated them as "Unreadable".

These results suggest that recycled flashcards are highly readable, allowing users to read the text without strain. Accordingly, Lin et al. (2018) emphasized that flashcards vary widely in their impact depending on how information is structured. Their study found that *conceptual* flashcards, which present ideas in a clear and simplified manner, resulted in better short-answer performance compared to detailed or overly dense flashcards, especially for less-skilled learners. This indicates that high readability supports deeper processing and reduces cognitive load.

B. Effectiveness of Using Recycled Flashcards as a Learning Tool

Table 5 Respondents' Scores

Number of Respondents (n)	Scores
1	16
2	20
3	10
4	20

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25dec456

5	20
6	19
7	19
8	19
9	10
10	20
11	20
12	20
13	20
14	18
15	19
16	20
17	20
18	20
19	17
20	20
21	20
22	19
23	15
24	15
25	14
26	15

Table 5 shows the scores of the 26 respondents on the Learning Retention Assessment. The majority of the respondents scored 20 out of 20 points with 12 respondents, indicating that most of the respondents demonstrated a strong understanding in the given Learning Assessment. Additionally, 11 respondents scored 15-19 points, and 3 respondents score 10-14 points. Overall, the results reflect a generally successful outcome of the group.

- *Range*

Range = Highest Value - Lowest Value

R = 21.5 - 19.5

R = 12

- *Approximate Number of Classes*

Using the Sturges' formula: k = 1+3.322 logN

Where: k = approximate number of classes

logN = logarithm of the total number of observation or raw data

k = 1+3.322 log(26)

k = 5.700541462

k ≈ 6

- *Class Interval (i) = Range/Number of Classes*

i = 12/6

i = 2

Table 6 Frequency Distribution of Respondents' Scores

Class	**Class Boundaries**	**f**	**x**	**<(cf)**	**fx**	**fx²**
20-21	19.5-21.5	12	20.5	26	246	60,516
18-19	17.5-19.5	6	18.5	14	111	12,321
16-17	15.5-17.5	2	16.5	8	33	1,089
14-15	13.5-15.5	4	14.5	6	58	3,364
12-13	11.5-13.5	0	12.5	2	0	0
10-11	9.5-11.5	2	10.5	2	21	441
∑		26			469	77,731

Shown in Table 6 is the grouped data which organizes the 26 test scores into class intervals from 10 to 21. The highest concentration of scores falls in the 20–21 interval, which indicates that most students performed very well. Only a few students scored in the lower intervals (10–13). The distribution shows that the dataset is positively skewed toward higher scores, meaning the overall performance of respondents is strong with the use of recycled flashcards. This result aligns with the journal of Senzaki et al. (2017), that

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25dec456

structured flashcard strategies can significantly improve students' academic performance.

➢ *Mean:* $\sum X/n$

$\bar{x}$ = 465/26

$\bar{x}$ = 17.88

Higher-class intervals (18–21), it suggests that many students achieved scores above the midpoint of the scoring range. This reflects generally strong academic performance.

➢ *Median:*

Median = $L + \frac{\left(\frac{N}{2} - <cf\right)}{f}\ i$

n/2 = 26/2 = 13

L = 17.5

<cf = 12

f = 6

i = 2

Based on the result, the computed median for the test scores of selected respondents is **17.67.** It means that half of the respondents scored below 17.67 and half scored above it. The median being close to the mean further suggests that the distribution of scores is balanced and not heavily skewed in either direction. This supports the idea that the students' performance is consistently high.

Mode: $L + (\frac{\Delta 1}{\Delta 1 + \Delta 2})$ i

L= 19.5

Δ1= 12-6 = 6

Δ2= 12- 0 = 12

I= 2

Based on the result, the computed mode for the weights of test scores is 20.17, which shows that the most frequently occurring scores fall around the highest interval (20–21). This means a significant portion of the respondents achieved very high scores. The mode being higher than both the mean and median indicates that many students scored near the maximum possible score.

Overall, the mean, median, and mode all lie in the upper range of the test scores, showing a strong overall performance among the respondents. The slightly higher mode suggests that many students scored exceptionally well, while the close values of the mean and median reflect consistent performance with minimal extreme scores.

➢ *Measures of Variation*

- *Variance:*

$$\sigma^2 = \frac{\sum (x - \bar{x})}{n-1}$$

$$\sigma^2 = \frac{228.6544}{26-1}$$

$$\sigma^2 = \frac{228.6544}{25}$$

σ^2=9.146176 ≈9.15

A variance of 9.15 indicates that the test scores are slightly spread around the mean of 17.88. This value shows that while there is some variability among the respondents' scores, the spread is not very large, meaning most students scored close to the average.

- *Standard Deviation:*

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

$$s = \sqrt{9.146176}$$

s=3.024264539 ≈3.02

The standard deviation of approximately 3.02 means that the scores typically vary by about 3 points above or below the mean. Since this value is relatively small compared to the scoring range, it implies that the students' scores are consistent, with no extreme outliers pulling the scores too far from the mean.

Overall, the variance and standard deviation values together show that the respondents' test scores are moderately consistent, with only minor differences among them. This suggests that the class performed uniformly well, with most students scoring within the same general range and no major gaps in performance.

C. Students' Experiences and Insights into Using Recycled Flashcards as an Eco-Friendly Study Tool

The table 7 below indicates the students' experiences using recycled flashcards as a study tool were overwhelmingly positive and meaningful, as evidenced by the high number of respondents who selected "Strongly Agree" or "Agree" for every statement, with zero students selecting "Disagree" or "Strongly Disagree." The most strongly supported finding was the overall assessment of a positive and meaningful experience, selected by 22 out of 26 students. This high consensus indicates that the tool was successful not only in its primary function but also in promoting secondary benefits. Academically, students found that the flashcards made studying more interesting and enjoyable and helped them efficiently recall and understand

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concepts, particularly in Thermochemistry. Furthermore, the use of recycled material strongly promoted environmental awareness and encouraged creativity and resourcefulness among the students, fulfilling the eco-friendly intent of the study.

Table 7 Respondents' Assessment of Recycled Flashcards

	Indicators	Weighted Mean	Verbal Interpretation	Rank
1	Using recycled flashcards made studying more interesting and enjoyable	3.73	STRONGLY AGREE	5.5
2	The flashcards helped me easily recall and understand Thermochemistry concepts.	3.65	STRONGLY AGREE	8
3	I became more motivated to study because of flashcards.	3.58	STRONGLY AGREE	10
4	The flashcards helped improve my focus while reviewing lessons.	3.69	STRONGLY AGREE	7
5	Working with recycled materials encourages creativity and resourcefulness.	3.77	STRONGLY AGREE	3.55
6	The recycled flashcards promoted environmental awareness and eco-friendly habits.	3.81	STRONGLY AGREE	2
7	The flashcards encourage interaction and discussion during group study.	3.73	STRONGLY AGREE	5.5
8	The flashcards make reviewing lessons more organized and efficient	3.77	STRONGLY AGREE	3.5
9	I would recommend using recycled flashcards to other students as a study tool.	3.62	STRONGLY AGREE	9
10	Overall, I had a positive and meaningful experience using recycled flashcards.	3.85	STRONGLY AGREE	1

Table 8. Despite the highly successful reception, the qualitative insights revealed a consistent area for improvement related to the physical properties of the recycled paper. Students explicitly recommended improving the durability and water resistance of the material for longer use, suggesting a potential trade-off between the eco-friendly nature and the longevity typically found in conventional study tools. While the recycled material was acknowledged as being well-chosen and functional, the repeated call to "Improve the durability" indicates that the physical sturdiness remains the chief practical concern identified by the users.

Table 8 Respondents' Insights and Experiences on Recycled Flashcards

Insights about the recycled flashcards.	It is useful because it is made up of recycled paper. I think It would better if it is more durable and water resistant for longer use. It was amazing, really a recycled material that can use in learning. The materials you used to create the photo cards are really well chosen. Despite it being created from recyclable stuffs, the flashcards still perform just as well as regular ones. The content remains clear and easy to understand, and the material doesn't get in the way of their function. The handwriting could have done better.
Experiences about recycled flashcards.	Maybe for experience none but in improvement is yung pagkakapareho ng cut atsaka yung kapal para di agad siya lumambot *(Maybe for experience, none, but in terms of improvement, it's the similarity in the cut and the thickness so it doesn't soften easily.)* Improve the durability

V. CONCLUSIONS

The recycled flashcard technique helped develop important pedagogical and creative skills in addition to memorizing. The study will verify that students' creativity and kinesthetic learning were stimulated by the practical process of making the flashcards, which involved gathering used materials and writing out chemical principles.

The study's primary secondary goal of fusing academic growth with environmental stewardship was well accomplished. The results will show how the project encouraged sustainable activities that were directly interwoven with academic work, thereby fostering environmental awareness and responsibility among the learners. The intervention validates the idea that educators can simultaneously address learning deficits and model mindful, responsible behavior toward sustainability and waste reduction by intentionally using recycled materials.

The study concludes that recycled flashcards provide a workable, scalable, and sustainable way to address low learning retention in core STEM courses. This novel approach, which connects ecological principles with high-impact teaching methods, offers a proven method for raising students' academic achievement and environmental

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conscience. As a best practice for fusing academic rigor with practical social responsibility, it is advised that this affordable and entertaining study aid be taken into consideration for inclusion in the regular curriculum.

RECOMMENDATIONS

➢ *The Following are Respectfully Advised by the Researchers Based on the Study's Findings:*

- Enhance the overall quality of the recycled flashcards by improving durability, uniformity of size, and resistance to damage.
- Conduct further testing on the recycled flashcards to gain deeper insights into their effectiveness and impact on learning retention.
- Adjust the process and materials used to further improve the flashcard's overall efficiency.
- Further investigate the applicability of the recycled flashcards across diverse learning environments.

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REFERENCES

[1]. Aba, L. (2019). Flashcards as a Media in Teaching English Vocabulary. Al-Lisan. https://www.neliti.com/publications/288920/flashcards-as-a-media-in-teaching-english-vocabulary#cite

[2]. Ansari, M. (2025). Sustainability through innovation and creativity in educational landscape: A systematic literature review analysis. Retrieved from https://www.sciencedirect.com/science/article/pii/S2666188825009943?fbclid=IwY2xjawObAf5leHRuA2FlbQIxMQBzcnRjBmFwcF9pZAEwAAEessc7K4O0u6mryfQaH3RWG8H1zTwj1EyHwl25r-O9tl8GiZM53UHqruY5E1Y_aem_uqLxSAHW3zaJ5fLhxExqLQ

[3]. Atai et al. (2024) Exploring the effectiveness of mobile assisted learning with digital flashcards in enhancing long-term retention of technical vocabulary among university students. J. Comput. Educ. 12, 1307–1332 (2025). https://doi.org/10.1007/s40692-024-00347-6

[4]. Cerbin, W. (2018). Research-Based guidelines for using flashcards to improve your learning. Taking Learning Seriously. https://www.takinglearningseriously.com/wp-content/uploads/2019/11/Flashcard-Guidelines.pdf?fbclid=IwY2xjawOLOT1leHRuA2FlbQIxMQBzcnRjBmFwcF9pZAEwAAEekVavRkLp9EmJP8IjLHeEPhxLjzeC5FBkbxADMyhXyJxDs9yaR3xGdDMhenM_aem_cPVFRxAwwQBqdVFeM9gMLw

[5]. Graulich, N. (2015). The tip of the iceberg in organic chemistry classes: how do students deal with the invisible?. Retrieved from https://doi.org/10.1039/c4rp00165f

[6]. Hatiningsih, N., & Adriyati, P. (2019). Implementing flashcard to improve the early reading skill. Retrieved from https://doi.org/10.2991/acpch-18.2019.71

[7]. Joshua. (2022, August 27). Why your students should be using flashcards. Caduceus. https://cipcourses.com/blog/why-your-students-should-be-using-flashcards/?fbclid=IwY2xjawOLN8pleHRuA2FlbQIxMQBzcnRjBmFwcF9pZAEwAAEegIBjdFibRTTrCHBmMsraz5SjvovII97Jsamg7GeIt-AtTj0V1ZglR4GZTYw_aem_13lVLVDjDlvvH3bwxoVyyQ

[8]. Memrizz. (2025, February 16). How to print flashcards: 6 things to remember. Memrizz Blog. Retrieved from https://www.memrizz.com/blogs/how-to-print-flashcards-6-things-to-remember

[9]. Miyatsu et al. (2018). Effects of Flashcards on Learning Authentic Materials: The Role of Detailed Versus Conceptual Flashcards and Individual Differences in Structure-Building Ability. Retrieved from https://www.researchgate.net/publication/326821129_Effects_of_Flashcards_on_Learning_Authentic_Materials_The_Role_of_Detailed_Versus_Conceptual_Flashcards_and_Individual_Differences_in_Structure-Building_Ability

[10]. Notedex. (2022, Jan 18). The ultimate guide to index card sizes. NoteDex Blog. Retrieved from https://www.notedexapp.com/blog/index-card-sizes

[11]. Pass, J. (2025, April 19). Exploring the effectiveness of flashcards for learning and retention — simply put psych. Simply Put Psych. https://simplyputpsych.co.uk/psych-101-1/exploring-the-effectiveness-of-flashcards-for-learning-and-

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retention?fbclid=IwY2xjawOLNT1leHRuA2FlbQIxMQBzcnRjBmFwcF9pZAEwAAEe49Bm890S5RAEWB5zSDahN0GZc4ldr0FmEvkqgznK8C38rrAZSFi95Uy0QHE_aem_mbqy_jKXXIJmIa7s9b_Vzg#google_vignette

[12]. Phelps, A. J. (2019). "But you didn't give me the formula!" and other math challenges in the context of a chemistry course. Retrieved from https://doi.org/10.1021/bk-2019-1316.ch007

[13]. Sage, K. D., Krebs, B., & Grove, R. (2019). Flip, Slide, or Swipe? Learning Outcomes from Paper, Computer, and Tablet Flashcards. Technology, Knowledge, and Learning. Retrieved from https://doi.org/10.1007/S10758-017-9345-9

[14]. Shultz, G. V., Gottfried, A. C., & Winschel, G. A. (2015). Impact of general chemistry on student achievement and progression to subsequent chemistry courses: A regression Discontinuity analysis. Retrieved from https://doi.org/10.1021/acs.jchemed.5b00209

[15]. Skreland, L. L., & Steen-Johnsen, T. (2021). The lamination machine and laminating as thing-power in early childhood pedagogical practice. Children S Geographies, 20(5), 701–713. Retrieved from https://doi.org/10.1080/14733285.2021.1965089

[16]. Sreekumar, D. (2025, July 23). What is Experimental Research Design? Definition, Types, and Examples | Researcher.Life. https://researcher.life/blog/article/what-is-experimental-research-design-definition-examples-types/

[17]. Take Care of Texas. (2023). Eco-Friendly Learning: Sustainable Practices in the Classroom. Retrieved from https://takecareoftexas.org/about-us/blog/eco-friendly-learning-sustainable-practices-classroom

[18]. Treagust D. F., Duit R., & Nieswandt M. (2000). "Sources of students' difficulties in learning Chemistry". Retrieved from https://doi.org/10.22201/fq.18708404e.2000.2.66458

[19]. Wilkes, C. L., Gamble, M. M., & Rocabado, G. A. (2024). Is general chemistry too costly? How different groups of students perceive the task effort and emotional costs of taking a chemistry course and the relationship to achievement and retention. Retrieved from https://doi.org/10.1039/d4rp00034j