Apple technological tools to enhance learning and motivation of Chinese Advanced Placement Biology students

Uso de herramientas tecnológicas de Apple para mejorar el aprendizaje y motivación de estudiantes chinos de cursos avanzados de Biología

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Abstract

The purpose of this research was to analyze the impact of the implementation of Apple's technological tools on the teaching, learning and motivation process of Chinese Advanced Placement (AP) Biology students. This study was carried out in a private High School in Shenzhen China during the 2021-2022 and 2022-2023 academic years. A quasi-experimental design was used with two different cohorts of 7 students, each enrolled in the AP Biology course. The Control Group (2021-2022 cohort, n=7) was taught using traditional instructional methods. On the other hand, the Intervention Group (2022-2023 cohort, n=7) received instruction with the incorporation of Apple technological tools, redesigned Keynote-based lesson materials, and other pedagogical interventions. Data were obtained through questionnaires, internal mid-term and final exams and the College Board's standardized AP Biology 2022 and 2023 exams. According to the analysis, the results of the Intervention Group showed a significantly higher final average score on internal assessments and an increase in College Board AP Biology standardized test scores, compared to control group results.

Therefore, students in the Intervention group outperformed the control group both in the Global average and the Chinese average in the College Board exam. Students' comments at the end of the course highlight the ease of use of Apple apps and hardware, and the attractive appearance of Keynote presentations contributing to increased motivation and engagement. These results support the idea that effective implementation of Apple technological tools in AP Biology instruction can significantly improve student motivation and learning, opening the door for future research in this field. This study acknowledges certain limitations, yet it simultaneously demonstrates that educational issues can be addressed from a pragmatic standpoint. The acquisition of knowledge regarding the intricacies of contemporary educational environments is paramount to ensure effective intervention. Teacher preparation is imperative to face the novel educational challenges of this era.

Keywords: Advanced Placement (AP); College Board; Biology education; Apple technological tools; Pedagogical intervention.

Resumen

El propósito de esta investigación fue analizar el impacto de la implementación de las herramientas tecnológicas de Apple en el proceso de enseñanza, aprendizaje y motivación de los estudiantes avanzados de Biología. Este estudio se llevó a cabo durante dos años en una escuela privada de nivel bachillerato en Shenzhen China durante los ciclos escolares 2021-2022 y 2022-2023. Se utilizó un diseño cuasi-experimental con dos cohortes diferentes de 7 estudiantes cada una inscrita en el curso de Biología AP. En el Grupo de Control (cohorte 2021-2022, n=7) se aplicaron métodos de enseñanza tradicionales, por otro lado, el Grupo de Intervención (cohorte 2022-2023, n=7): recibió instrucción que incorporaba herramientas tecnológicas de Apple, materiales de lección rediseñados basados en Keynote y otras intervenciones pedagógicas. Los datos se obtuvieron a través de cuestionarios, exámenes internos parciales y finales y los exámenes estandarizados AP Biology 2022 y 2023 del College Board. Según el análisis, los resultados del Grupo de Intervención mostraron una puntuación media final significativamente más alta en las evaluaciones internas y un aumento en las puntuaciones de los exámenes estandarizados de Biología AP del College Board, en comparación con los resultados del Grupo de Control. Por lo tanto, los estudiantes del Grupo de Intervención superaron al Grupo de Control tanto en la media global como en la media china en el examen del College Board. Los comentarios de los estudiantes al final del curso destacan la facilidad de uso de las aplicaciones y el hardware de Apple, y el aspecto atractivo de las presentaciones de Keynote, que contribuyen a aumentar la motivación y el compromiso. Estos resultados apoyan el planteamiento de que la implementación eficaz de las herramientas tecnológicas de Apple en la enseñanza de la biología AP puede mejorar significativamente la motivación y el aprendizaje de los estudiantes. Este estudio reconoce ciertas limitaciones, pero al mismo tiempo demuestra que las cuestiones educativas pueden abordarse desde un punto de vista pragmático. La adquisición de conocimientos sobre los intrincados problemas de los entornos educativos contemporáneos es primordial para garantizar una intervención eficaz. La preparación del profesorado es imprescindible para afrontar los nuevos retos educativos de esta época.

Palabras clave: Colocación Avanzada (AP); College Board; Enseñanza de la biología; Herramientas tecnológicas de Apple; Intervención pedagógica.

INTRODUCTION

China is a challenging teaching environment due to the strict central government control over the flow of information, which is permanently monitored and censored (Creemers, 2016; Shyu, 2008). This can lead to self-censorship and its negative impact on personal and collective creativity (Klotzbücher et al., 2020). Many parents are aware that the public education sector often sacrifices the quality of teacher training for the mass production of educators (Zhou, 2019), and those who are financially able choose to enroll their children in private international schools that teach the American Advanced Placement curriculum to guarantee a higher quality education for their children, so that they can migrate abroad to go to a U.S. university. This is where my teaching adventure begins. I was hired by an international academy in China to teach AP Biology and have been lecturing on this subject for 3 years and 3 months. It should be noted my training as an evidence-based physician suggested me to perform quantitative research totally adhering to the scientific method. However due to the complexity of social studies and the intricacies of human individuality coupled with the knowledge acquired in the Master's degree in Education opened the door for me to implement a dialectical research action methodology with a quasi-experimental model to be more practical, have the possibility to solve problems and adhere to the principles of the so-called "new pedagogy" (Osmanović Zajić & Maksimović, 2022).

In this article, Apple's technological tools are defined as software that is compatible with the Apple ecosystem, which includes: applications such as Keynote, various iOS compatible applications, and hardware such as iPads and MacBooks. Apple's technological tools provide an intuitive and seamless experience due to the effective integration of its software and hardware (Dempsey, 2019). In the educational environment, it has been shown that the use of the iPad can improve student grades (Corey, 2019; Funaro, 2014), both parents and students perceive a dramatic improvement in student motivation when using Apple products in the teaching-learning process (Eppard et al., 2022), and an atmosphere of community and belonging is created that favors collaborative work in the classroom (Kuo & Kuo, 2020). However, not all teachers are trained for its effective use (Ferguson & Oigara, 2017). The adaptation and implementation of a curriculum taught via iPad presents significant challenges (Stec et al., 2018), so it is recommended that teachers who serve students with these technological preferences be trained for its use through Apple teacher certification and the study of similar cases (Tarazi & Arafat, 2021).

METHODOLOGY

This study employed a quasi-experimental design, specifically a non-equivalent control group design to evaluate the impact of Apple technological tools on student learning and motivation in an Advanced Placement (AP) Biology course. The research spanned two academic years (2021-2022 and 2022-2023) and involved two different cohorts of students enrolled in a private international high school in Shenzhen, China.

Study Design and Participants

A total of 14 students of Chinese nationality were included in this study; 7 different students per academic year. It should be clarified that this study did not follow the same cohort of students for two consecutive years, but studied two different generations of 7 students each who attended the AP Biology class, which are described as follows:

Control Group (2021-2022 academic year cohort, n=7): Students in this group were taught using traditional instructional methods without the integration of Apple technological tools.

Intervention Group (2022-2023 academic year cohort, n=7): This different group of students received instruction that incorporated Apple technological tools, redesigned Keynote-based lesson materials, and other pedagogical enhancements.

No tools were applied to explore in-depth demographic or socioeconomic data on an individualized basis due to privacy and internal personal data protection policies.

Since students were assigned to academic years based on school enrollment rather than random assignment, this study meets the criteria for a quasi-experimental design. The comparison was made between two distinct, consecutive cohorts rather than within the same group of students over two years.

Inclusion Criteria

To ensure consistency, participants in both groups met the following criteria:

- Enrollment in the AP Biology course at our Academy.
- Registration for the College Board AP Biology exam corresponding to their academic year.
- Native Mandarin Chinese speakers with American English as a second language.
- On-campus housing for students with relatively similar academic backgrounds and career aspirations in life sciences.

Procedure

Phase 1: Baseline Assessment (2021-2022 Academic Year, Control Group)

During the first academic year, started in August 2021 and concluded in June 2022, a prospective analytic cohort study was conducted to examine students' learning habits, motivation, and technological tool preferences. The following methods were employed:

Survey #1: "Use of Technologies in the Classroom" (10 multiple-choice questions) to assess student preferences regarding learning tools.

Observation and Performance Monitoring: Student engagement and academic performance were measured through internal mid-term and final examinations.

AP Biology 2022 Standardized Test Scores: Used as an external assessment to evaluate learning outcomes.

At the conclusion of this phase, low student motivation was identified as a key challenge, prompting the development of a pedagogical intervention. It should be noted that at the time of my hiring it was explained to me that the low student motivation was a chronic problem previously identified in prior academic cycles. This information was provided verbally by the head of the Department of Science.

Phase 2: Pedagogical Intervention (2022-2023 Academic Year, Intervention Group)

Based on findings from Phase 1, a pedagogical intervention incorporating Apple technological tools was implemented in the second academic year. The intervention followed 7 steps, described in the Table 1. (See Table 1)

Table 1
Stages of the pedagogical intervention

Stage	Characteristics
Diagnosis	Survey #1 "Use of technologies in the classroom", personal reflection, exploration of student motivation, analysis of results including data from the control cohort, and a personal analysis as a teacher to identify my strengths and weaknesses.
Objectives	Improve the teaching, learning and motivation process of the AP Biology class through the use of Apple's technological tools.
Strategies	Teacher Preparation (Myself): Received Apple Teacher Certification and training in the effective use of Apple software and hardware for educational purposes. Lesson Redesign: Conversion of instructional materials into Keynote presentations using a Macbook, following recommendations from Apple Distinguished Educators and Apple's educational community and after consideration of the students' favorite slide design to achieve an attractive and meaningful pattern. Integration of Apple technological tools: Use of iPads, Apple Pencil, MacBooks, Keynote, and various iOS-compatible applications to enhance engagement and enrich the teaching, learning and motivation process and the Apple Teachers in Action.
Implementation	2022-2023 academic year in AP Biology students. The group that received the pedagogical intervention was exposed to an enriched-modified instructional environment for one year, according to the strategies designed to meet the objectives of this pedagogical intervention.
Monitoring	Motivation Assessment Monitoring: Application of Survey #2: "Motivation in my Biology Class" (15 Likert-scale items) to assess students' motivation levels at different stages of the academic year. Performance Monitoring: Analysis of students' mid-term and final exam scores to track academic progress.
Evaluation	Final Evaluation: Comparison of College Board AP Biology 2023 exam scores with the previous year's cohort.
Final feedback	Student Feedback: Survey #3: "Individual Student Perception of the Motivational Outcome of Using Apple Educational Tools", where students reflected on the impact of Apple tools on their motivation at the end of the course answering the following question: Do you consider that the implementation of Apple's educational recommendations and the use of Apple's technological tools helped to improve your motivation as a student in our class?

Data Collection and Analysis

To measure the effectiveness of the pedagogical intervention, the following data sources were analyzed: Surveys: Responses from Surveys #1, #2, and #3. Internal Academic Performance Data: Mid-term and final examination scores for both cohorts. External Standardized Test Scores: Official AP Biology exam results from College Board (2022 & 2023). Qualitative Student Feedback: Open-ended responses regarding student experiences with Apple technological tools.

Ethical Considerations

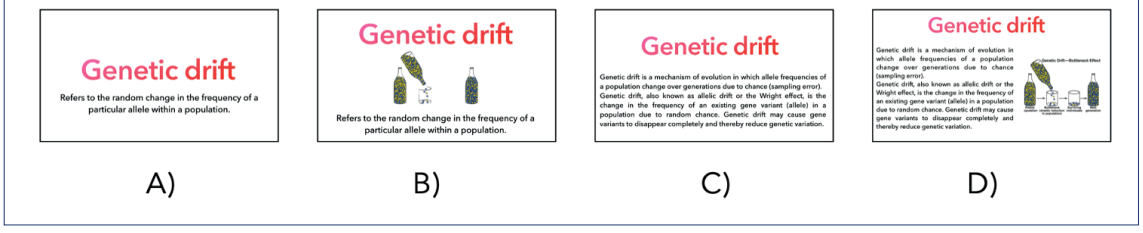
Participation was voluntary, and all students were informed about the study objectives. No personal or sensitive data were collected beyond academic performance and survey responses. The study adhered to internal school policies on data protection and student confidentiality.

This quasi-experimental approach allowed for a comparative analysis of student motivation, learning engagement, and academic performance while acknowledging the study's limitations, including the absence of randomization and potential individual differences between cohorts (Osmanović Zajić, 2022). Apple technological tools such as an iPad, a MacBook, Apple Keynote and iOS compatible software were added. Likewise, recommendations of the Apple educational community included teacher training, redesign of the classes and slides, as well as student preferences, which will be explained as follows.

At the beginning of the second school year, the students were asked about their favorite design, and 100% of them chose design B), which corresponds to the key concept along with an image. (See Figure 1)

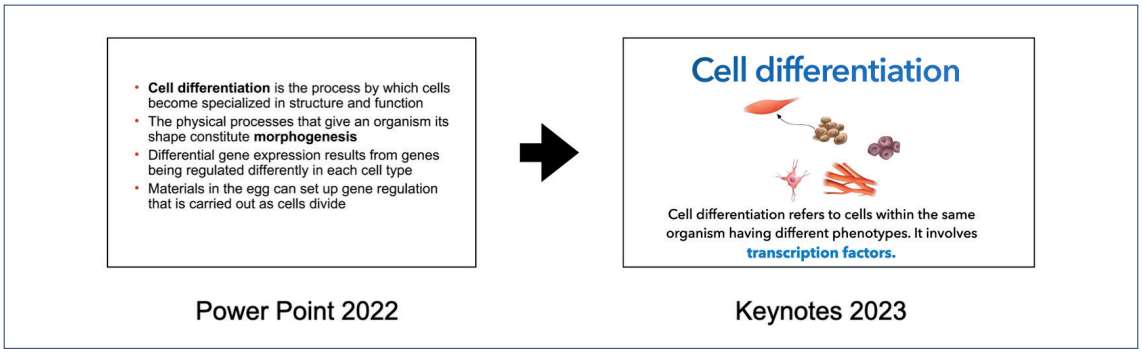
Figure 1

Survey to explore the slide design preferred by students.



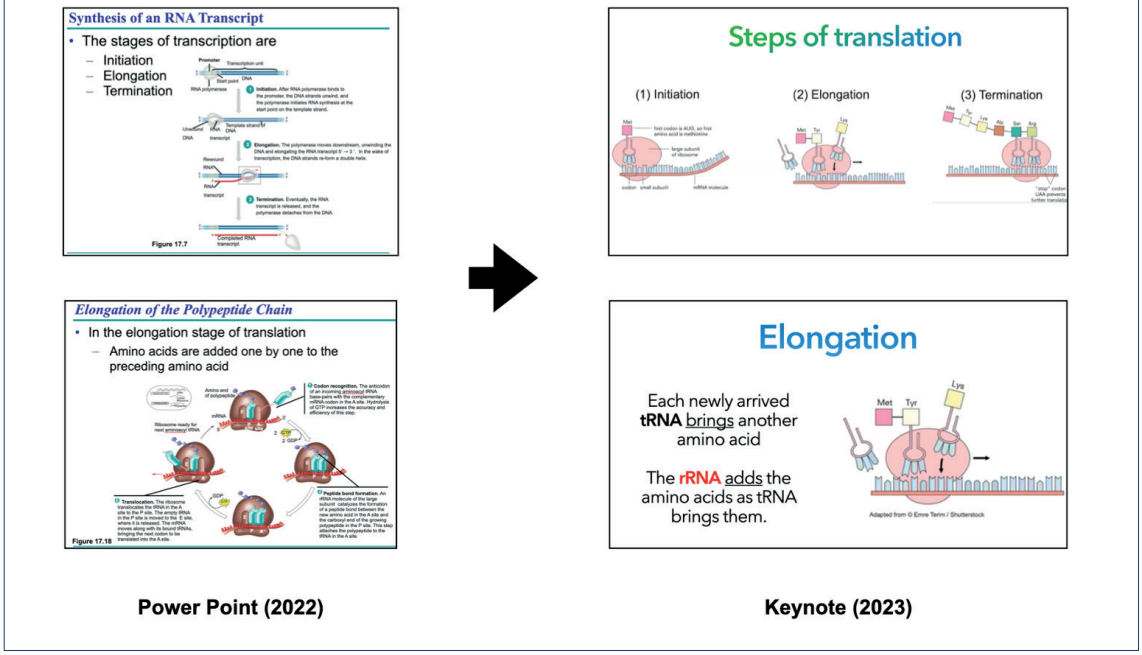
After the preferences of my students were identified, all the slides provided by my institution were redesigned, colors were added to the concepts, and a minimalist style corresponding to the key concept along with an illustrative image was adopted. This design motivated the students to pay more attention in class and take notes more frequently. The following image is an example of the new appearance of the slides. (See Figure 2)

Figure 2
Example of slide redesign using keynote following my students' preferred layout: Key concept + illustrative image.



Restructuring the PowerPoint slides removes unnecessary text, which can be replaced by the teacher's explanation. Complex and small images are substituted by meaningful diagrams that easily convey the concept or topic at hand. Titles, topics and key words are highlighted with bold and eye-catching colors so that the student is able to identify them at all times. The slides serve as audiovisual support for the class and are not intended to completely replace or have greater prominence than other pedagogical elements. However, they played an essential role for the students who were eager to take notes and pay attention to the class (See figure 3)

Figure 3
Examples of the redesign and adaptation of the slides following the recommendations of the Apple educational community.



As for the integration of Apple's technological tools in my daily teaching practice, A MacBook M3 pro was used as a working tool to plan lessons and create Keynote slides. An 11-inch iPad Pro M1 was used, connected via Wi-Fi to the multimedia screen in my classroom for daily teaching. This allowed me to walk freely around the classroom and interact with the students. Also, a second-generation Apple Pencil was used to take notes and add text on the iPad, which was then displayed on the screen.

Some of the applications we used in the classroom were:

- Apple Notes and Pages. Mainly for note-taking in class; some students also used them for homework.
- Atlas. Visible Body. I used this app to interactively display anatomical structures in the classroom in augmented reality.
- Freeform. It was helpful to create real-time collaborative environments, concept maps and brainstorming.
- Pick Me. A roulette that helped me to randomly select students for class participation without any selection bias error.
- Keynote: Slide design and presentation was also a good tool for image editing.
- Stikbot Studio 2. It was helpful to make simple stop motion videos.
- Numbers. We created lists and glossaries of terms.
- Clips. With it we made funny review videos using previously elaborated models.

A detailed explanation of the use and application of each and every one of these applications in the classroom is impossible given the limited length of this article. However, they can be discussed in subsequent papers.

The Apple educational community on its website provides a self-taught learning center with classes and tutorials, which through the correct resolution of tests at the end of each module provides medals that can be accumulated to obtain recognition as an Apple teacher. This certification helped me to obtain a sufficient domain to use the software and hardware for educational purposes. Likewise, it empowered me to solve technical problems of my students when they used these tools.

RESULTS

Survey #1: "Use of Technologies in the Classroom"

In relation to note-taking in class, a clear trend towards the use of Apple devices was observed. Only 4% of students used Windows PCs for this activity, while none of the students surveyed took notes with Android tablets.

In terms of reading, the iPad was identified as the preferred device, used by 51% of students. It is relevant to note that the textbook and the traditional notebook were selected by 22% of respondents, while 11% chose the Windows computer. No student used devices with the Android OS for reading.

In the area of multimedia content consumption, Apple products, including the iPad and MacBook, were the most preferred among students, with a high 79% preference. This contrasted with 18% who used Windows PC devices and 4% who opted for Android hardware products.

It was observed that the most commonly used tool for homework was electronic hardware, with a notable 77% of students selected this option. Within this group, 81% chose Apple devices to complete their academic assignments. This highlighted the effective integration of technology into the homework completion process, with a significant preference for Apple products.

Regarding personal preference and satisfaction, Apple products were clearly the most chosen. A total of 72% of students opted for hardware from this brand, with the iPad being the most enjoyed device, receiving a remarkable 80% preference, while the MacBook accounted for 20%. These results emphasized the strong connection students had with Apple products in their daily lives and educational experiences. Approximately 40% of the students spent from 2 to 3 hours per day using the keyboard on their electronic devices.

Meanwhile, 60% of the students used touch-screen technology for an interval of 4 to 5 hours per day. Handwriting using touch-screen technology emerged as the dominant preference, representing a solid 81% of students, while digital keyboard writing comprised 19% of the total preference. Interestingly, the preference for handwriting was particularly evident in the use of a stylus pen on electronic devices, highlighting a clear attachment to the handwriting experience even in a digital environment.

These results provide a richer understanding of students' preferences and habits regarding information capture and writing, as well as an overview of how students interact with available technologies, while highlighting the continued relevance of handwriting even in the digital age.

Survey #2 "Motivation in my Biology Class"

This survey was applied in the monitoring phase, with the assumption that student motivation was relatively low at the beginning of the academic year due to the factors discussed above.

Survey #2, "Motivation in My Biology Class," was designed to assess motivation specifically within the field of biology. In this survey, responses were recorded on a five-point Likert scale, where 5 indicated strong agreement, 4 agreement, 3 partial agreement, 2 disagreement, and 1 strong disagreement. Intrinsic (IM), extrinsic (EM), and mixed motivators (MM) related to professional development were measured, and after calculating the averages for each motivation category, the following results were obtained. The items assessing intrinsic motivation (IM) yielded an average of 4.6, while those measuring extrinsic motivation (EM) and mixed motivation (MM) produced averages of 3.8 each.

Results of the Internal Exams in the Monitoring Phase

The impact of Apple's technological tools on students' learning processes was monitored using the scores obtained in the first and second semesters of the AP Biology course,

as well as the final course scores across two academic years. A comparative methodology was employed, analyzing student groups from the Control Group and the Intervention Group. The objective was to determine whether any significant difference in academic performance emerged over the course of a school year as a result of the implementation of these technological tools.

The following tables present the collected data. The first table (See Table 2) displays the scores obtained by the Control Group class during the 2021-2022 academic year. This table includes four columns: the first column lists the number of students, the second column presents the final course score, which represents the average of the first and second semester scores, provided in the third and fourth columns, respectively. The second table (See Table 3) displays the scores obtained by the Intervention Group class during the 2022-2023 academic year.

The final class average for the Control Group was 75.81. (See Table 2).

Table 2
Scores obtained by the Control Group.

Students	Final average score of the AP 2021-2022 class per student	Average score of the AP 2021-2022 class per student in the second semester	Average score of the AP 2021-2022 class per student in the first semester
Student 1	90.25	92.01	88.5
Student 2	91.5	94	89
Student 3	78.8	73.1	84.5
Student 4	88.25	93	83.5
Student 5	71.55	70.1	73
Student 6	34.52	30.05	39
Student 7	71.96	66.42	77.5

The final class average for the Intervention Group was 90.14, as shown in the table below (See Table 3).

Table 3
Scores obtained by the Intervention Group.

Students	Final average score of the AP 2022-2023 class per student	Average score of the AP 2022-2023 class per student in the second semester	Average score of the AP 2022-2023 class per student in the first semester
Student 1	92.05	93.42	90.69
Student 2	91.93	94.61	89.24
Student 3	90.06	90.53	89.6
Student 4	85.05	87.6	84.4
Student 5	87.7	90.06	85.34
Student 6	88.84	90.88	86.8
Student 7	95.39	95.46	95.33

Student scores on the College Board 2022 and 2023 AP Biology exams

According to the 2022 official report obtained from https://scores.collegeboard.org, 85.7% of the students in the 2022 cohort of 7 students scored 3 or higher. Thirteen percent achieved a score of 5, 50% of the students scored 4, 25% scored 3, 0% scored 2, and 13% scored 1. (See Table 4 with attached bar graph).

Table 4

Comparative percentage distribution of AP Biology 2022 exam scores of the Control Group versus the percentage distribution in China and the rest of the Globe. https://scores.collegeboard.org

Score	Control Group	China	Global
1	14.3% 1 student	5.2%	8.0%
2	0% 0 students	9.5%	19.4%
3	14.3% 1 student	21.5%	28.4%
4	57.1% 4 students	34.0%	25.0%
5	14.3% 1 student	29.8%	19.2%

Note. Adapted from AP Biology Student Performance Report 2022. College Board.

According to the 2023 official report obtained from College Board's official website, a 100% success rate was recorded among the seven students in the Intervention Group, all obtaining a score of 3 or higher. A score of 4 was achieved by 57.14% of the students, while 28.57% attained the highest score of 5, and 14.25% obtained a score of 3. (See Table 5 with attached bar graph).

Table 5

Comparative percentage distribution of AP Biology 2023 exam scores of the Control Group versus the percentage distribution in China and the rest of the Globe.

Score	Intervention Group	China	Global
1	0% 0 students	5.4%	12.5%
2	0% 0 students	9.4%	21.7%
3	14.25% 1 student	21.4%	24.8%
4	57.14% 4 students	29.2%	21.9%
5	28.57% 2 students	34.7%	19.1%

Note. Adapted from AP Biology Student Performance Report 2023. College Board.

The mean score on the 2023 AP biology exam of the Intervention Group was 4.14. This is above the global mean of 3.04 and China's mean of 3.78.

Results of survey #3 "Individual Student Perception of the Motivational Outcome Using Apple Educational Tools"

Below, the Intervention Group students' responses to the question: "Do you feel that the implementation of Apple's educational recommendations and the use of Apple's technological tools helped you improve your motivation as a student in our class? Please support your answer and explain why" are presented.

When asked about their motivation, student 1 noted: Yes, I definitely feel that incorporating Apple's technological tools into our AP Biology class has improved my motivation. I used to find some parts of the subject matter a bit overwhelming, but using the iPad and the apps on a daily basis make everything easier. Plus, it feels good that Rochin knows how to use technology and teach me things I don't know, rather than the other way around. Most teachers have trouble using technology.

Student 2 Response. "Yes. Even though I don't have an iPad, the slides look super nice and that motivates me to be in biology class, taking notes becomes easy when everything is displayed so clearly. However, I believe this stuff can also be done with Microsoft."

Student 3 response. "Of course it does! Apple stuff makes learning biology less boring and more exciting; I am a fan of the brand and that motivates me. I liked that Rochin helped me focus when I was distracted."

Student 4 Response. "Definitely yes, the stuff we do on the iPad and the cool presentations make me want to be in class more."

Student 5 response. "Yes. The keynotes and apps make it easier to understand."

Student 6 Response. "Yes, the classes are very dynamic, I like using the iPad because then I can forget about carrying books and notebooks that are very heavy and get in the way."

Student 7 response. "It's great that our teacher knows how to use Apple tech. Rochin always helps me when I have problems with my iPad. It helps us connect better. It was a good year."

ANALYSIS

The results of the monitoring phase highlight the predominance of intrinsic motivators in student motivation in biology class. External incentives, although necessary, do not have such a significant impact on students' motivation, and mixed motivators show a moderate level of appreciation by students. These findings provide valuable information for adapting pedagogical strategies and designing activities that strengthen the intrinsic motivators that drive students' motivation in their biology learning process.

The distribution of AP Biology 2022 exam scores shows a large variability among students in the Control Group, indicating that there are significant differences in the level of academic performance. It is important to analyze the low performance causes in this single student and design strategies to improve his performance in future academic years, since the same pedagogical methods were applied to all students equally. On the other hand, the scores distribution of the AP Biology 2023 exam scores is mostly concentrated in the high-scoring region, with the lowest mark recorded as three. This indicates a significant improvement in the overall performance of the class compared to that of the previous year's class. These results suggest that the pedagogical intervention had a positive impact on students' achievements, resulting in a more favorable grade distribution and a higher average score on the AP Biology standardized test. However, it is necessary to explore

additional variables that were not considered in this study but may have influenced the improved results observed among students who received the pedagogical intervention.

Student responses at the end of the course corroborated that the integration of Apple's technological tools, applications, and engaging Keynote slides contributed to a more dynamic and interactive learning environment.

CONCLUSIONS

The comparative analysis between both cohorts demonstrates an evident improvement in academic performance among students in the Intervention Group, who achieved an average final score of 90.14 in the internal AP Biology evaluations, compared to 75.81 in the Control Group. This substantial increase suggests that the integration of Keynote slide design strategies, Apple's technological tools, and educational recommendations contributed positively to both student motivation and learning outcomes.

Additionally, when analyzing performance on the standardized AP Biology exam administered by the College Board, an increase in the mean score of the Intervention Group (4.14 in 2023) compared to the Control Group (3.57 in 2022) was observed. While this difference may not be statistically significant, it holds pedagogical importance, as an increase in scores on externally assessed standardized exams reflects an improvement in the fulfillment of curricular objectives. These findings highlight the potential of technology-enhanced instructional strategies to foster higher engagement and academic achievement in rigorous science courses.

Finally, although technology favors the learning process, the teacher's intervention is important and indispensable to analyze and reflect on the topics.

PROPOSALS FOR IMPROVEMENT

We acknowledge the limitations of this study. However, future iterations will aim to refine the methodology and expand the sample size to include a more diverse student population, allowing for a more comprehensive analysis of the intervention's impact. We encourage educators to conduct research on students' technological preferences and learning habits to develop targeted instructional strategies that enhance engagement and academic achievement.

Ongoing professional development is essential to remain aligned with evolving pedagogical and technological advancements. Further research is needed to examine the potential benefits of artificial intelligence, virtual reality, and augmented reality in educational settings. Advancing these areas of study will support both educators and students in creating dynamic and innovative learning environments. We sincerely hope that this study contributes to the enhancement of teaching practices.

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