Effect of Consumption of Digital Content Related to Biology on Shaping the Attitude of Students Towards Biology and Achievement in Biology of Students at Higher Secondary Level.

Abstract

The growing use of digital content in education has reshaped how students engage with subjects like Biology. This study investigates the relationship between higher secondary students' consumption of Biology-related digital content, their attitude toward the subject, and academic achievement. It also examines differences based on gender and educational board (CBSE vs. WBCHSE).

Using a quantitative survey method, the study found a strong positive correlation between students' attitudes and their achievement in Biology, and a moderate positive correlation between digital content consumption and attitude. However, no direct link was found between digital content consumption and achievement. While gender had no significant effect on content use or achievement, boys showed a more positive attitude than girls. CBSE students reported higher content usage and more favorable attitudes than WBCHSE students.

These findings suggest that positive attitudes, more than digital content volume, are key to academic success in Biology. The study emphasizes the importance of integrating credible, well-chosen digital resources to foster student engagement and improve learning outcomes.

Keywords:

Digital Content Consumption, Biology Education, Academic Achievement, Student Attitude, Digital Literacy, Online Learning Resources, Instructional Materials, Credible Digital Resources

1. Introduction:

1.1. Introduction:

Digital content in education refers to the use of digital tools and resources in the teaching and learning process. It includes the use of technology to present information, facilitate communication, and access various online resources. The importance of credibility and reliability in digital content is crucial. With the vast amount of information available on the

internet, it is necessary to evaluate the credibility of sources to ensure the accuracy and trustworthiness of the information. The credibility of digital content can be assessed based on factors such as accuracy, authority, aesthetics, professionalism, popularity, currency, impartiality, and quality. Ensuring the credibility and reliability of digital content is essential to avoid using subjective opinions or false information as references in educational settings. The evaluation of credibility can be done by both humans and computers, and a hybrid approach that combines important variables from both methods can produce reliable results. The ability to find and utilize credible digital content is important for students' research and writing processes.

The unique place of instructional materials as integral component of curriculum and instruction has traditionally been grossly misunderstood and correspondingly neglected. This is evidenced by the different phrases used to describe them and some of these are: “teaching aids”, and “audiovisual aids” and “apparatus”. However, with the electronic evolution of the field brought about by the involvement of different interest groups such as educational technologists, curriculum development specialists, management specialists, educational psychologists, educational evaluators, and researchers coupled with the incursion of technological products, the earlier phrases used to describe instructional materials have failed to adequately describe them. These advantages include the fact that electronic information sources are often faster than consulting print indexes, especially when searching retrospectively. They are straighter forward when wishing to use combinations of keywords. They open up the possibility of searching multiple files at one time, a feat accomplished more easily than when using printed equivalents. Electronic resources can be printed and searches saved to be repeated at a later date; they are updated more often than printed tools. Also, they are available from outside the library by dial-up access. The changes in the education sector have exerted pressure upon the traditional teaching; thereby, causing changes in teaching and learning methods, towards a greater emphasis on student cantered learning due to technological developments. This caused an increase in the availability of electronic information sources which has being significant within the teaching and learning.

Currently most biology teachers strive to provide students with a large amount of empirical knowledge. Digital resources of the information search have become so accessible that they can be used to find the required biological facts so quickly that it is not so important to remember large amounts of these empirical data. The most important results of biological

education include the ability to solve practical life problems, universal competencies, and creativity. There is a great variety of digital educational resources in biology (electronic manuals, programs, simulators, virtual simulations etc.). It is rather problematic to navigate them, and, moreover, efficiently apply digital technologies in the educational process without special auxiliary instruments. According to the studies, the use of digital technologies in the educational process depends, first of all, on the proper selection.

Previous studies investigating how students' academic achievement correlates with digital literacy, for example Tang and Yen (2016) have found that a higher level of digital literacy has a positive effect on students' success in a blended learning environment. Mehrvarz et al. (2021) revealed the same effect, but also highlighted the importance of informal learning that takes place outside academia for digital literacy. In contrast, Abbas et al. (2019) found no correlation between digital literacy and academic achievement; however, the study revealed a large difference in the level of digital literacy across different areas of literacy. While there are several studies showing a correlation between digital literacy and academic achievement (Tadesse et al., 2018), some studies have shown no correlation (Katz and Macklin, 2007). Thus, the findings of previous studies were heterogeneous and did not provide a clear picture. In an online course, everything can be administered via digital channels—general information, course content, exercise materials, synchronous communication with students and teachers, and examinations. This places greater demands on students' digital literacy and more and more consumption of digital contents.

Hence, this study mostly focuses on the correlations between the students' attitude and achievement in the subject biology with the quantity of digital content consumption they are having with respect to the subject.

1.2. Emergence of the Study:

The emergence of studies examining the effects of consuming digital content related to biology on shaping students' attitudes toward the subject and their achievement at the higher secondary level is a response to the increasing integration of technology in education and the need to understand its impact. With the proliferation of digital platforms, educational content has become more accessible, interactive, and engaging than ever before.

These studies typically explore how various forms of digital content, such as videos, simulations, interactive quizzes, and online modules, influence students' attitudes towards biology and their academic performance. Here's how they may approach the research:

Attitude Formation: Researchers might investigate how exposure to digital content affects students' attitudes towards biology. This could involve measuring changes in students' interest, motivation, perception of relevance, and perceived difficulty of the subject before and after exposure to digital materials.

Engagement and Learning Styles: They may explore how different types of digital content cater to diverse learning styles and preferences among students. For example, some students may prefer visual learning through animations and videos, while others may benefit more from interactive simulations or text-based resources.

Impact on Learning Outcomes: Studies might assess the relationship between consuming digital biology content and academic achievement in the subject. This could involve comparing the performance of students who regularly engage with digital resources to those who primarily rely on traditional textbooks and classroom instruction.

Long-term Effects: Researchers may also investigate whether the effects of digital content consumption on attitudes and achievement in biology are sustained over time or if they diminish after the initial exposure.

Factors Influencing Effectiveness: Additionally, studies might examine contextual factors that influence the effectiveness of digital content, such as students' prior knowledge, access to technology, teacher support, and the quality of the digital materials used.

Overall, the emergence of such research highlights the importance of understanding how digital resources can be effectively leveraged to enhance students' attitudes towards biology and improve their academic performance in the subject, particularly at the higher secondary level where foundational knowledge and interest in STEM fields are crucial for future academic and career pursuits.

1.3. Statement of the Problem:

"Effect of Consumption of Digital Contents Related to Biology on Shaping the Attitude of Students Towards Biology and Achievement in Biology of Students in Higher Secondary Level".

1.4. Objectives of the Study:

Current research is aimed to find out the relatedness and impact of the consumption of digital contents in Biology subject on attitude of the students on the subject and achievement in the

subject Biology. The following research objectives were designed to expand existing research concerning consumption of digital contents in the biology subject to:

O_1: To measure the level of digital content consumption related to the subject Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

O_2: To study the attitude towards Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

O_3: To measure the achievement in Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

O_4: To compare the level of digital content consumption related to the subject Biology, attitude towards Biology and achievement in Biology between boys and girls students studying at Higher Secondary Level in the southern districts of West Bengal.

O_5: To compare the level of digital content consumption related to the subject Biology, attitude towards Biology and achievement in Biology between WBCHSE and CBSE Board students studying at Higher Secondary Level in the southern districts of West Bengal.

O_6: To compare the digital content consumption related to the subject Biology of students studying at Higher Secondary Level in the southern districts of West Bengal under the gender and Board of studies categorical variables.

O_7: To compare the attitude towards Biology of students studying at Higher Secondary Level in the southern districts of West Bengal under the gender and Board of studies categorical variables.

O_8: To compare the level of achievement in Biology of students studying at Higher Secondary Level in the southern districts of West Bengal under the gender and Board of studies categorical variables.

O_9: To study the relationship between content consumption related to the subject Biology and the attitude toward Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

O_{10}: To study the relationship between content consumption related to the subject Biology and the achievement in Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

O_{11}: To study the relationship the attitude toward Biology and the achievement in Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

1.5. Hypotheses of the Study:

$H_0$1: There is no significant difference in level of digital content consumption related to the subject Biology between the Boys and Girls students studying at Higher Secondary Level in the southern districts of West Bengal.

$H_0$2: There is no significant difference in attitude towards Biology between the Boys and Girls students studying at Higher Secondary Level in the southern districts of West Bengal.

$H_0$3: There is no significant difference in achievement in Biology between the Boys and Girls students studying at Higher Secondary Level in the southern districts of West Bengal.

$H_0$4: There is no significant difference in level of digital content consumption related to the subject Biology between the students studying in WBCHSE and CBSE Board at Higher Secondary Level in the southern districts of West Bengal.

$H_0$5: There is no significant difference in attitude towards Biology between the students studying in WBCHSE and CBSE Board at Higher Secondary Level in the southern districts of West Bengal.

$H_0$6: There is no significant difference in achievement in Biology between the students studying in WBCHSE and CBSE Board at Higher Secondary Level in the southern districts of West Bengal.

$H_0$7: There is no significant difference among the groups of students considering the gender of students and the board of their study taken together (boys of WBCHSE board, boys of CBSE board, girls of WBCHSE board, girls of CBSE board) in their level of digital content consumption related to the subject Biology at Higher Secondary Level in the southern districts of West Bengal.

$H_0$8: There is no significant difference among the groups of students considering the gender of students and the board of their study taken together (boys of WBCHSE board,

boys of CBSE board, girls of WBCHSE board, girls of CBSE board) in their attitude towards Biology at Higher Secondary Level in the southern districts of West Bengal.

$H_0$9: There is no significant difference among the groups of students considering the gender of students and the board of their study taken together (boys of WBCHSE board, boys of CBSE board, girls of WBCHSE board, girls of CBSE board) in their achievement in Biology at Higher Secondary Level in the southern districts of West Bengal.

$H_0$10: There is no significant relation between the level of digital content consumption related to the subject Biology and attitude towards Biology among the students studying at Higher Secondary Level in the southern districts of West Bengal.

$H_0$11: There is no significant relation between the level of digital content consumption related to the subject Biology and achievement in Biology among the students studying at Higher Secondary Level in the southern districts of West Bengal.

$H_0$12: There is no significant relation between the level of attitude towards Biology and achievement in Biology among the students studying at Higher Secondary Level in the southern districts of West Bengal.

1.6. Operational Terms and Definitions:

For a study on the effect of consumption of digital content related to biology on shaping the attitude of students towards biology and their achievement in biology at the higher secondary level, you might consider the following operational terms and definitions:

i. **Consumption of Digital Content:** The act of accessing, viewing, interacting with, or utilizing digital materials, including but not limited to videos, animations, simulations, e-books, websites, and educational apps, specifically related to the subject of biology.

ii. **Attitude towards Biology:** The psychological disposition or inclination of students towards the subject of biology, including their feelings, opinions, beliefs, and behavioral tendencies related to biology as a field of study.

iii. **Achievement in Biology:** The level of academic success or proficiency attained by students in the subject of biology, typically measured by scores on tests, assessments, exams, or other academic evaluations that assess knowledge, understanding, and application of biological concepts.

iv. **Higher Secondary Level:** The educational stage typically encompassing grades 11 and 12, also known as the final years of secondary education before entering tertiary education or the workforce, depending on the educational system.

v. **Digital Content:** Any material or information presented in electronic format, including text, images, audio, video, or interactive media, that is accessible through digital devices such as computers, tablets, smartphones, or other digital platforms.

vi. **Shaping:** The process of influencing or moulding the attitudes, beliefs, perceptions, or behaviours of individuals over time through exposure to various stimuli, including digital content related to biology in the context of this study.

vii. **Student:** An individual enrolled in a formal educational institution at the higher secondary level, typically within the age range of 16 to 18 years, who is the focus of the study.

viii. **Effect:** The impact, influence, or outcome resulting from the consumption of digital content related to biology on students' attitudes towards biology and their achievement in the subject, which may include changes in perceptions, interests, motivation, learning outcomes, or academic performance.

ix. **Operationalization:** The process of defining abstract concepts, such as attitude towards biology and achievement in biology, in measurable and observable terms suitable for empirical investigation and data collection within the context of the study.

These operational terms and definitions provide clarity and specificity regarding the key concepts and variables under investigation in the study, facilitating consistent interpretation and analysis of research findings.

1.7. Delimitations of the Study:

i. The study will be delimited to the Southern districts of West Bengal.

ii. The study will be delimited in the urban parts of the Southern Districts of West Bengal.

iii. Only Higher Secondary school students of class XI affiliated to WBCHSE and CBSE will be considered.

iv. The content area for the achievement test will be selected from each unit of the class XI Biology curriculum which are common in both the curriculums of WBCHSE and CBSE boards.

1.8. Significance of the Study:

The significance of the study titled "Effect of Consumption of Digital Contents Related to Biology on Shaping the Attitude of Students Towards Biology and Achievement in Biology of Students at Higher Secondary Level" lies in its potential to contribute valuable insights into the intersection of digital learning, student attitudes, and academic achievement in biology education.

Digital Learning Impact: In an increasingly digital world, understanding how digital content consumption influences learning outcomes is crucial. This study can shed light on the effectiveness of digital resources in the context of biology education, providing educators with evidence-based insights into the benefits and limitations of incorporating digital content into their teaching methods.

Attitude Formation: Attitudes play a significant role in learning outcomes. By examining how exposure to digital biology content shapes student attitudes towards the subject, the study can reveal whether digital resources have a positive or negative impact on student engagement, motivation, and perception of biology. This information can inform the development of strategies to cultivate a more positive attitude towards biology among students.

Academic Achievement: Academic achievement in biology is a key measure of educational success. By investigating the relationship between digital content consumption and academic performance in biology, the study can identify factors that contribute to student success and provide insights into how educators can optimize the use of digital resources to enhance learning outcomes.

Implications for Teaching Practices: The findings of this study can inform teaching practices in biology education. Educators can use the insights gained to adapt their instructional strategies, curriculum design, and the selection of digital resources to better meet the needs and preferences of students, ultimately improving learning experiences and outcomes in biology education.

Future Research Directions: This study can also pave the way for future research exploring related areas such as the impact of specific types of digital content, the role of technology integration in biology curriculum development, and the effectiveness of digital learning environments in promoting deeper conceptual understanding and critical thinking skills in biology.

Overall, the significance of this study lies in its potential to advance our understanding of the complex relationship between digital content consumption, student attitudes, and academic achievement in biology education, with implications for both theory and practice. Which includes the benefits of:

- **Students:** Students will understand the significance of referring to digital content related to Biology in their preparation in the subject Biology in Higher Secondary level.
- **Teachers:** Teachers will be able to find out relevance of integrating digital contents as a part of their teaching contents in the subject Biology in Higher Secondary level.
- **Administrations of Schools:** The school administrations will be able to figure out the significance of integrating ICT facilities and other digital learning aids as infrastructure development policies in schools relevant to the subject Biology in Higher Secondary level.
- **School Management Boards:** They will have clear picture on the extent of required inclusion of usage of digital contents in the curriculum relevant the subject Biology in Higher Secondary level.
- **Planning Commissions and Policy Makers:** The respective board, committees and syllabus or curriculum formulators will also get a measurement of the required quantity of inclusion of digital contents in the subject Biology in Higher Secondary level.
- **Researchers:** Future researchers will be helped with the outcomes of this study to use as references in their future endeavours in the same line of researches.
- **Parents:** Parents will have a clear picture about the need and extent of exposure of their child towards digital contents related the subject Biology in Higher Secondary level in their wards' preparations.

2. Review of Related Literature:

2.1. Indian Literature:

When conducting a literature review on the effect of digital content consumption related to biology on student attitudes and achievement at the higher secondary level in India, several relevant articles provide valuable insights:

i. Sharma and Sharma (2018) conducted a study titled "Impact of Digital Learning Resources on Secondary School Students' Attitude Towards Biology", investigating the influence of digital learning resources on students' attitudes towards biology. The study was situated in the Indian context and highlighted how exposure to interactive digital tools, animations, and simulations significantly improved students' interest and positive disposition towards biology.

ii. Singh (2019), in the study "The Role of Digital Media in Enhancing the Learning Experience of Biology at Secondary Level in India", examined the role of digital media in improving biology learning experiences. The findings indicated that students exposed to digital media such as educational videos and gamified learning apps demonstrated a more positive attitude towards biology compared to those who relied on traditional resources.

iii. Bhattacharya (2017), in the article "Digital Technology and Science Learning: Indian Context", explored the integration of digital technologies in science education. While the study broadly covered science learning, it emphasized that digital content helped make abstract biological concepts more concrete, contributing positively to student attitudes. Bhattacharya (2017) also discussed how digital content serves as a catalyst in improving conceptual understanding, leading to enhanced academic outcomes.

iv. Patil and Patil (2018) investigated the *"Effectiveness of Digital Learning Materials in Learning Biology at Higher Secondary Level"*. The study assessed the impact of digital learning materials like animated videos, quizzes, and interactive simulations on

academic achievement. Results showed that students who used digital content scored higher in post-tests compared to those taught through conventional methods.

v. Gupta and Reddy (2020), in their study titled *"Digital Content and Learning Outcomes in Biology: A Study Among Higher Secondary Students in India"*, analyzed the correlation between digital content usage and academic achievement. Their findings suggested a positive relationship, noting that frequent digital content users performed significantly better in biology assessments.

By reviewing these articles and synthesizing their findings, a comprehensive understanding of how digital content consumption related to biology influences student attitudes and achievement at the higher secondary level in India can be gained. Common themes, methodological approaches, and gaps in the existing literature can be looked for to inform in the proposed research study.

2.2. Literature from Abroad:

When examining relevant articles from outside India on the effect of digital content consumption related to biology on student attitudes and achievement at the higher secondary level, consider the following studies:

i. Cheung and Slavin (2013), in their meta-analysis *"The Impact of Digital Learning Content on Student Learning Outcomes"*, reviewed multiple international studies across subjects including biology. They concluded that digital learning content significantly improved student achievement, especially when the content was interactive and tailored to student needs.

ii. Higgins, Beauchamp, and Miller (2007) examined *"Digital Technology and Student Learning: The Impact of Interactive Whiteboards"* and found positive effects on student engagement and understanding. Although the study did not focus on biology, it underscored the potential of digital tools in enhancing learning outcomes.

iii. Tarng and Tsai (2012), in their research *"The Impact of Digital Educational Resources on Secondary School Students' Motivation for Learning Science"*, revealed that students exposed to digital resources demonstrated increased motivation and more favorable attitudes toward science, including biology.

iv. Lin and Hwang (2010), through the study *"Effects of Multimedia Instruction on Students' Attitudes and Science Learning"*, demonstrated that multimedia instruction

not only boosted learning outcomes but also improved students' interest and attitudes toward science subjects.

v. Schmid et al. (2014) in their meta-analysis *"The Impact of Digital Technologies on Teaching and Learning in K-12 Education"*, highlighted a consistent trend of improved academic performance and enhanced student engagement across various disciplines due to the use of digital technologies.

By reviewing these articles alongside the Indian literature, a complete understanding of the effects of digital content consumption on student attitudes and achievement in biology education at the higher secondary level is obtained. These can be considered to synthesize findings from both domestic and international studies to inform your research study effectively.

2.3. Literatures Directly Related to the Operational Terms of the Study:

2.3.1. The integration of digital

Technology in education has transformed traditional teaching methods, offering new opportunities to enhance student learning experiences (Villegas-Reimers, 2019). In the field of science education, particularly biology, digital content has become increasingly prevalent, providing students with interactive and multimedia resources to explore complex biological concepts (Gore & Banks, 2020).

2.3.2. Attitude Formation and Influence

Attitudes towards biology are shaped by various factors, including teaching practices, curriculum design, and societal perceptions of science (Sadler, 2009). According to the Theory of Planned Behavior (Ajzen, 1991), attitudes are influenced by individual beliefs about the consequences of their actions, subjective norms, and perceived behavioral control. Therefore, exposure to engaging and relevant digital content may positively influence students' attitudes towards biology by enhancing their perceived value and interest in the subject (Wang et al., 2018).

2.3.3. Role of Digital Content in Education

Digital content offers unique advantages in biology education, allowing students to visualize abstract concepts, conduct virtual experiments, and access a wealth of multimedia resources

(Smetana & Bell, 2012). Interactive simulations, educational games, and online platforms provide opportunities for active learning and personalized instruction, catering to diverse learning styles and preferences (Means et al., 2013). Furthermore, digital resources can foster collaborative learning environments, encouraging student engagement and participation in biology-related activities (Marino & Beecher, 2017).

2.3.4. Effects of Digital Content on Attitudes towards Biology

Research suggests that exposure to digital content positively impacts students' attitudes towards biology. For example, a study by Zheng et al. (2016) found that students who utilized online videos and interactive animations demonstrated greater interest and motivation towards biology compared to those using traditional textbooks. Similarly, research by Ching et al. (2018) reported that incorporating multimedia presentations and virtual labs into biology instruction improved students' perceptions of the subject and their confidence in understanding complex biological phenomena.

2.3.5. Effects of Digital Content on Achievement in Biology

The use of digital content has been associated with improved academic achievement in biology. Meta-analytic studies by Cheung & Slavin (2013) and Tamim et al. (2011) found that the integration of digital technology in science education resulted in higher student achievement scores and increased retention of biological knowledge. Furthermore, interactive simulations and virtual dissections have been shown to enhance students' conceptual understanding and problem-solving skills in biology (Plass et al., 2014).

2.3.6. Challenges and Considerations in Using Digital Content

Despite its potential benefits, the effective integration of digital content in biology education presents several challenges. Access to technology and reliable internet connectivity remain significant barriers, particularly in underserved communities (Warschauer, 2014). Moreover, ensuring the quality and accuracy of digital resources requires careful vetting and ongoing evaluation by educators (Harris & Hofer, 2011). Additionally, digital content should be thoughtfully integrated into curriculum planning to complement rather than replace traditional teaching methods (Hsu et al., 2017).

This literature review provides a comprehensive overview of existing research on the effect of digital content consumption on student attitudes and achievement in biology, laying the groundwork for the proposed study at the higher secondary level.

2.4. Literatures Consulted for Developing the Tools:

2.4.1. Digital Content Consumption and Media Use:

i. Prensky (2001), in his seminal article "Digital Natives, Digital Immigrants," introduced the concept of digital natives—students who have grown up in a world saturated with technology. He argued that these learners think and process information fundamentally differently from previous generations. This work provides a crucial theoretical foundation for understanding students' preferences for digital content consumption, highlighting that digital natives are more comfortable with interactive, multimedia-rich content. It also implies that educational strategies, particularly in subjects like biology, must align with their digital learning habits to be effective.

ii. Karpinski et al. (2009), in the study "The Role of Digital Media in Students' Learning," explored how students' use of digital media platforms affected their academic engagement and performance. While the study acknowledged potential distractions from non-academic digital content, it also found that structured and curriculum-aligned use of digital media could enhance learning experiences. The findings stress the importance of purposeful integration of digital resources in education and offer insights into how such media can influence students' academic outcomes and attitudes toward subjects like biology.

Research examining how digital media influences students' learning and engagement can guide your understanding of what content might be relevant for your questionnaire.

2.4.2. Educational Technology and Digital Learning:

i. Clark and Mayer (2016), in their comprehensive work "E-learning and the Science of Instruction," discussed evidence-based principles of instructional design tailored for digital learning environments. The book emphasized the importance of multimedia principles, learner engagement, and cognitive load management in e-learning. Their research-based guidelines are highly relevant to biology education, where complex concepts can be made accessible through well-structured digital content. The text supports the present study by providing a theoretical basis for understanding how students interact with digital materials and how such content should be designed to improve both attitudes and learning outcomes.

ii. The OECD (2015), in its report titled "The Impact of Digital Technology on Learning: A Summary for the Education Sector," analyzed global data to assess how digital technology influences learning outcomes. The report concluded that while technology can enhance learning, its effectiveness depends on how it is integrated into the teaching-learning process. It warned that indiscriminate use of digital tools does not automatically lead to improved performance. Instead, meaningful use aligned with pedagogical goals tends to yield positive results in student achievement and engagement. This insight reinforces the need to examine both the quality and the context of digital content consumption in shaping student attitudes and achievement in biology education.

The OECD report provides a comprehensive overview of how digital technology affects learning, which can help in designing questions about the effectiveness of digital resources.

2.4.3. Student Engagement and Learning Preferences:

i. Fredricks, Blumenfeld, and Paris (2004), in their influential study "Student Engagement and Student Learning: Testing the Linkages," conceptualized student engagement as a multifaceted construct involving behavioral, emotional, and cognitive dimensions. Their research demonstrated that each type of engagement significantly contributes to learning outcomes. This framework is highly relevant when analyzing the influence of digital content, as different formats (e.g., videos, simulations, quizzes) may target different engagement domains. The study supports the current research by offering a theoretical lens through which the impact of digital content on students' interaction with biology can be better understood.

ii. An empirical study titled "The Influence of Learning Preferences on Students' Engagement and Achievement in Biology" (author/year unspecified) examined how students' preferred learning styles affected their participation and performance in biology classes. The findings indicated that when instructional methods—including digital content—aligned with students' learning preferences (visual, auditory, kinesthetic), there was a marked improvement in both engagement and academic achievement. This study underscores the importance of personalized digital content that resonates with diverse learners, offering further justification for investigating how digital content consumption shapes attitude and achievement in biology.

Research that specifically focuses on biology students' learning preferences can help tailor your questions to the subject matter.

2.4.4. Assessment and Measurement in Education:

i. Bourne and Thomas (2009), in their book "Designing and Using Instruments for Educational Research," provided comprehensive guidelines for developing valid and reliable instruments for educational studies. Their work emphasizes key principles such as construct validity, reliability testing, and questionnaire design — all of which are essential in educational research involving attitudinal and achievement-related variables. This text is particularly relevant to the present study as it supports the development of the Likert scale questionnaire used to measure students' attitudes toward biology in the context of digital content consumption.

ii. The study titled "Measuring the Impact of Digital Resources on Student Learning Outcomes" (author/year unspecified) focused on identifying appropriate indicators and instruments for assessing the effectiveness of digital content in improving academic performance. It emphasized the need for both quantitative and qualitative data to capture the multi-dimensional effects of digital resources, such as enhanced comprehension, motivation, and retention. The study also discussed assessment tools that can evaluate learning gains attributable to digital media. These insights are instrumental in guiding the measurement strategies employed in the present research.

Studies that assess the impact of digital resources on learning can provide examples of how to frame questions about the effectiveness and utilization of digital content.

2.4.5. Context-Specific Studies:

i. The study titled "Technology Integration in Indian Schools: A Case Study of West Bengal" (author/year unspecified) focused on how digital tools and infrastructure are being implemented in schools across West Bengal. The findings highlighted disparities in access, teacher preparedness, and student exposure to digital resources. It also emphasized the urban-rural divide and infrastructural limitations that influence the effectiveness of technology-enhanced learning. For the present study, which targets higher secondary students in India, such regional insights are critical in understanding the local conditions that shape digital content consumption and its impact on student attitudes and academic achievement in biology.

ii. The article "Educational Technology in Indian Schools: Challenges and Opportunities" (author/year unspecified) examined the broader Indian educational landscape with respect to technology integration. The study discussed systemic challenges including teacher training gaps, unequal distribution of resources, and curriculum alignment issues. However, it also identified growing opportunities through government initiatives, increasing digital literacy, and the proliferation of low-cost educational apps and online platforms. These contextual factors help situate the present study within the realities of Indian education and validate the need to explore how digital content influences student engagement and outcomes in subjects like biology.

2.5. Literature Matrix of Review of Literature:

A Literature review matrix which is presented below will summarize the major findings found by the present researcher through review of Literature.

Table 2.1.: A Literature review matrix about major findings found by the present researcher through review of literature.

Researcher/s	Year	Place	Study Design	Variables Considered in Research with Results			Findings
				Independent Variables	Dependent Variables		
					Dependent Variables	Categorical Variables	
Sharma, S., & Sharma, S.	2018	India	Quantitative	Digital learning resources	Attitude scores	Use of digital resources (Yes/No)	Improved attitudes towards biology.
Bhattacharya, K.	2017	India	Qualitative	Integration of digital technology	-	Integration type (low, medium, high)	Positive impact on engagement.
Singh, M.	2019	India	Mixed Methods	Role of digital media	Enhancement of biology learning experience	Access to digital media (Yes/No)	Enhanced learning experiences.
Bhalera	2016	India	Correlational	Attitudes towards	Achievemen	Attitude level	Positive

o, A., & Khot, S.				biology	t in biology	(positive, neutral, negative)	correlation found.
Patil, S., & Patil, N.	2018	India	Experimental	Use of digital learning materials	Learning outcomes in biology	Exposure to digital content (Yes/No)	Improved learning outcomes.
Gupta, A., & Reddy, P.	2020	India	Quantitative	Digital content usage	Learning outcomes and attitudes towards biology	Digital usage frequency (low, medium, high)	Positive impact on outcomes.
Cheung, A. C., & Slavin, R. E.	2013	International	Meta-Analysis	Digital learning content	Student learning outcomes across subjects	Subject-specific performance data	Significant positive effects found.
Higgins, S., Beauchamp, G., & Miller, D.	2007	International	Mixed Methods	Interactive whiteboard usage	Learning outcomes in secondary education	Frequency of interactive whiteboard use	Improved active learning.
Tarng, W., & Tsai, M.	2012	Taiwan	Quantitative	Digital educational resources	Motivation for learning science	Resource type (interactive, static)	Boosted student motivation.
Lin, T. C., & Hwang, G. J.	2010	Taiwan	Experimental	Multimedia instruction	Attitudes towards science and learning outcomes	Multimedia exposure type (video, animation, interactive)	Improved attitudes and achievement.
Schmid, R. F., et al.	2014	International	Meta-Analysis	Digital technologies	Teaching and learning effectiveness	Technology integration level (basic, advanced)	Enhanced teaching and learning.

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2.6. Critical Appraisal of Reviewed Literatures:

Critical appraisal involves evaluating the strengths, weaknesses, and overall quality of the literature reviewed for a study. Here's a critical appraisal of the related literature relevant to the study:

2.6.1. Strengths:

i. **Theoretical Frameworks:** Many of the reviewed studies grounded their research in established theoretical frameworks, such as the Theory of Planned Behavior and Social Cognitive Theory. This theoretical foundation provides a solid basis for understanding the psychological mechanisms underlying attitude formation and behavior change in response to digital content consumption.

ii. **Empirical Evidence:** Several studies cited in the literature review presented empirical evidence supporting the positive effects of digital content consumption on student attitudes towards biology and achievement in the subject. These findings contribute valuable insights into the potential benefits of integrating digital technology in biology education.

iii. **Diverse Methodologies:** The literature review encompassed studies employing diverse methodologies, including experimental research, surveys, and meta-analyses. This methodological diversity enhances the robustness of the findings and allows for a comprehensive examination of the research questions from multiple perspectives.

2.6.2. Weaknesses:

i. **Limited Longitudinal Studies:** Many of the reviewed studies relied on cross-sectional or short-term experimental designs, which may limit their ability to assess the long-term effects of digital content consumption on student attitudes and achievement in biology. Longitudinal studies tracking students' progress over an extended period would provide more definitive insights into the sustained impact of digital technology on learning outcomes.

ii. **Heterogeneity of Digital Content:** The literature encompassed a wide range of digital resources, including videos, simulations, games, and virtual labs. While this diversity reflects the richness of digital content available in biology education, it also complicates comparisons across studies and makes it challenging to isolate the specific features or characteristics of digital content that contribute to its effectiveness.

iii. **Contextual Factors:** Many studies did not adequately account for contextual factors, such as socioeconomic status, prior academic achievement, and teacher quality, which may influence the relationship between digital content consumption and student outcomes. Failure to control for these confounding variables could limit the generalizability of the findings and obscure the true effects of digital technology on student learning.

2.6.3. Overall Assessment of the Review of related literature:

The reviewed literature provides compelling evidence that consumption of digital content related to biology can positively impact student attitudes towards the subject and their achievement in biology at the higher secondary level. However, the field would benefit from more rigorous longitudinal studies that control for contextual factors and investigate the differential effects of various types of digital content. Additionally, future research should explore the mechanisms underlying these effects and identify strategies for optimizing the integration of digital technology in biology education. Despite these limitations, the existing literature offers valuable insights into the potential of digital content to enhance teaching and learning experiences in biology classrooms.

2.7. Conclusion and Research Gaps Identified:

The literatures suggest that the consumption of digital content related to biology positively influences students' attitudes towards the subject and their academic achievement at the higher secondary level. However, further research is needed to explore the long-term effects of digital content usage on student learning outcomes and to identify strategies for addressing the challenges associated with its integration into biology education and no correlation has been investigated among the variables like scientific attitude, achievement in biological science, extent of consumption of digital content etc.

3. Methodology:

3.1. Research Methodology:

A quantitative research methodology to be tailored for the study on the effect of consumption of digital contents related to biology on shaping the attitude of students towards biology and achievement in biology at the higher secondary level:

3.1.1. Research Design:

Quantitative study will be performed, which will be a survey that is descriptive in nature. Tools like questionnaire, achievement scale, aptitude scales will be developed to collect data.

3.1.2. Variables:

3.1.2.1. Major Variable:

a) Digital content consumption related to the subject Biology (Independent Variable)
b) Attitude towards biology (Dependent Variable)
c) Achievement in biology (Dependent Variable)

3.1.2.2. Demographic/ Categorical Variables:

a. Gender of the Student (Girl and Boy)
b. Board of Study (CBSE and WBCHSE)

3.2. Research Tool:

3.2.1. Tools of the Study:

i. **Digital content consumption related to the subject Biology:** A tool with 5-point rating scale, named DCCB (Digital Content Consumption of Biology) will be developed by the researcher for the study (Appendix - I).
ii. **Attitude towards biology:** A self-made tool with 5-point rating scale, ATTB (Attitude Towards Biology) will be developed to measure the attitude of students for the study (Appendix - II).
iii. **Achievement in biology:** A survey will be done to the respective shortlisted CBSE and WBCHSE board schools to get the Biology Achievement Test scores of the students in the Annual Examinations of the respective schools and from that Z-scores will be calculated as this will convert data values into a standard normal distribution.
iv. **Data Analysis:** 29^{th} version of the software SPSS (Statistical Packages for Social Sciences) will be used for analysing the data related to the study.

- Both the tools (scales) namely **DCCB** and **ATTB** were constructed by the present researcher with the help of the Research Guide. Initially total items were 35 which were brought down to 32 after expert validation. The categories of responses were Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree and 5, 4, 3, 2, 1 were the respective scores to be awarded for the responses. Some items are negative in nature and the scoring to be done in reverse order in those case like 1, 2, 3, 4, 5.

Reliability of Tools:

- **ATTB Scale** (32 items): Cronbach's Alpha = **0.933** (High reliability)
- **DCCB Questionnaire** (32 items): Cronbach's Alpha = **0.712** (Acceptable reliability)

3.3. Data Collection Procedure:

The researcher will personally collect the data by physically visiting the schools and administering the two tools of the study.

To determine the Achievement score, the researcher will appeal to the respective schools to provide with the Annual Examination Scores of the students in Biology, and then that data will be analysed by virtue of calculating the Z-scores of the same as Z-scores convert data values into a standard normal distribution.

3.4. Sampling Method:

3.4.1. Stratified Random Sampling:

Sampling Method: Stratified Random sampling method will be followed for selecting the samples from the population.

3.4.2. Data Analysis:

Statistical Techniques: Appropriate statistical techniques were employed to examine relationships between variables and to test the hypotheses. Descriptive statistics were used to summarize the data. Pearson's correlation analysis was applied to assess relationships between digital content consumption and attitude or achievement in biology.

Student's t-test was conducted to compare mean scores across gender and board affiliations. For comparisons among more than two groups, Analysis of Variance (ANOVA) was used.

When significant differences were found through ANOVA, post hoc tests were performed. All analyses were conducted at the 0.05 level of significance.

3.5. Research Sample:

Population: Students studying at Higher Secondary Level in the southern districts of West Bengal belonging to the WBCHSE and CBSE Boards.

Sample Size:

A pool of 257 students were selected from various schools of southern part of West Bengal.

Table 3.4.: Gender of Student wise Sample.

Gender of Students wise Sample					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Girl	99	38.52%	38.52%	38.52%
	Boy	158	61.48%	61.48%	100.0
	Total	257	100.0%	100.0%	

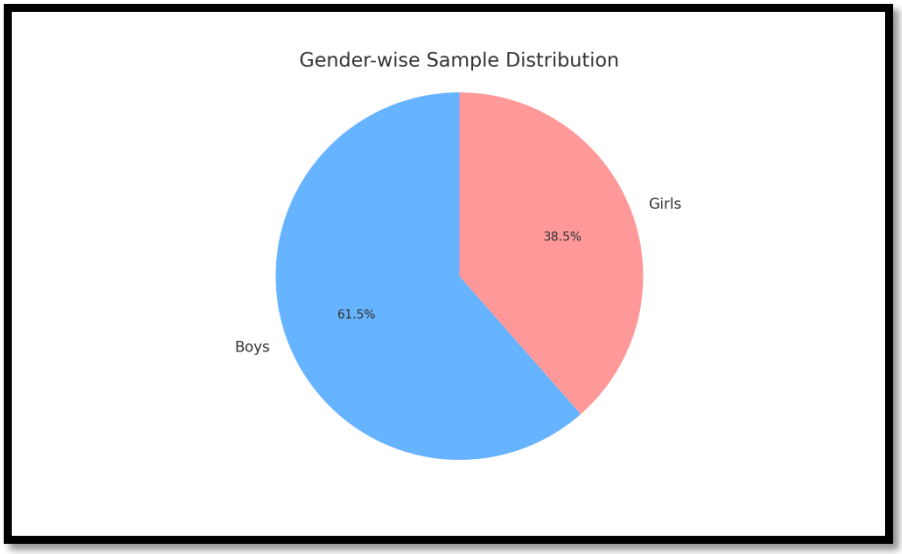

Fig. 3.1. Gender of Student wise Sample

Table 3.5.: Board of Study of the Student wise Sample.

School Board of Students wise Sample					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**CBSE**	124	48.25%	48.25%	48.25%
	WBCHSE	133	51.75%	51.75%	100.0%
	Total	257	100.0%	100.0%	

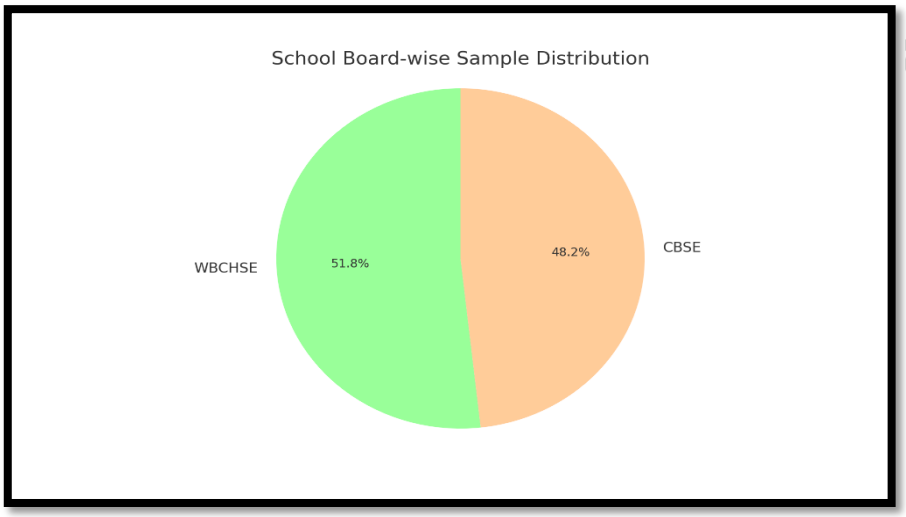

Fig. 3.2. Board of Study of Student wise Sample

Table 3.6.: Strata wise Sample.

Gender Strata wise Sample					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Girl CBSE**	53	20.62%	20.62%	20.62%
	Girl WBCHSE	46	17.90%	17.90%	38.52%
	Boy CBSE	71	27.63%	27.63%	66.15%
	Boy WBCHSE	87	33.85%	33.85%	100.0%
	Total	257	100.0%	100.0%	

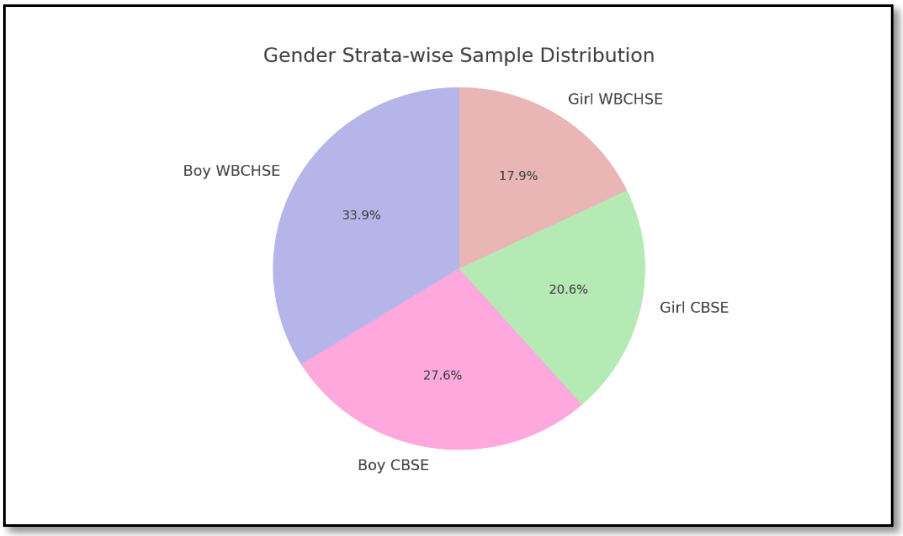

Fig. 3.3. Gender-Strata wise Sample

3.6. Presentation of Data:

All the raw data were tabulated in MS Excel version 2021 and further analyses were done in IBM SPSS 29.0 version by importing data from excel file.

- IBM SPSS 29.0 Version:

IBM SPSS Version 29.0 is a comprehensive statistical software suite widely used for data analysis, management, and reporting across various fields, including education, business, healthcare, and social sciences. It offers robust tools for handling large datasets, transforming data, and performing both basic and advanced statistical analyses. Key features include descriptive statistics, t-tests, ANOVA, regression, non-parametric tests, and advanced options like factor and cluster analysis.

3.6.1. Descriptive Statistics: Attitude Towards Biology (ATTB)

Statistic	**Value**
N (Valid Cases)	257
Mean	118.74
Standard Deviation	17.89
Median	119.00
Minimum	73
Maximum	160

Range	87
Skewness	-0.407
Kurtosis	-0.534
95% Confidence Interval (CI)	[116.55, 120.94]

Table: 3.7. Descriptive Statistics of Attitude Towards Biology

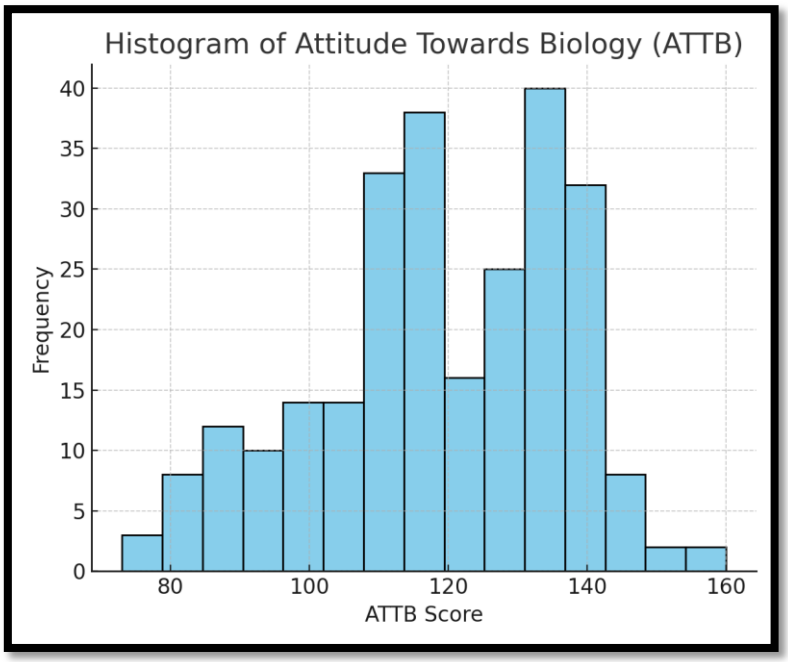

Fig. 3.4. Histogram _ ATTB

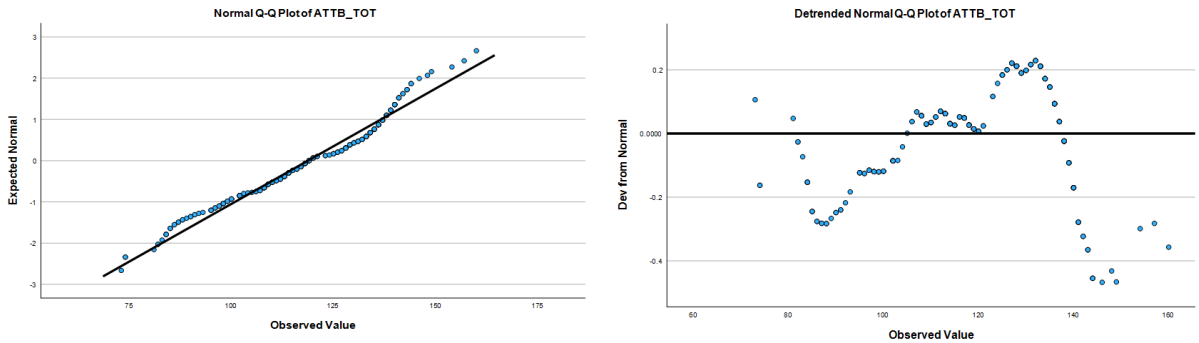

Fig. 3.5. Normal and Detrended Normal Q-Q Plot for ATTB_TOT

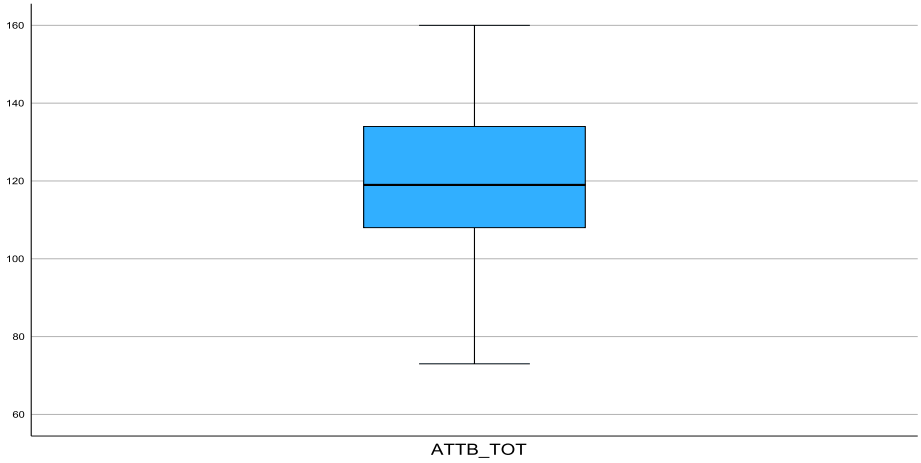

Fig. 3.6. Box Plot ATTB_TOT

Interpretation: The attitude scores are fairly symmetrically distributed (skewness ≈ 0) and show moderate variability. The average score of 118.74 indicates a **moderately positive attitude** among higher secondary students toward Biology.

Group Statistics of Attitude Towards Biology (ATTB)

- **By Gender**

Gender	N	Mean	Std. Deviation	Std. Error Mean
Boys	158	121.00	16.839	1.340
Girls	99	115.14	18.992	1.909

Table: 3.8. Group Statistics of Attitude Towards Biology (ATTB) _ Gender wise

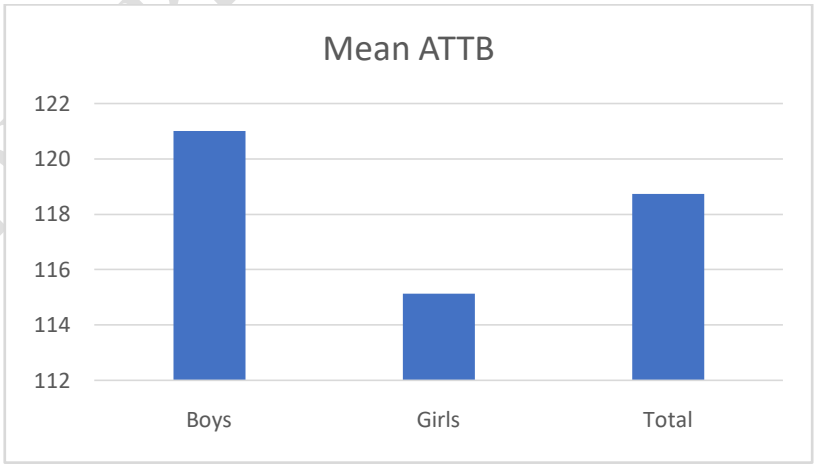

Fig. 3.7. Group Statistics of ATTB _ Gender Wise

- **By Board**

Board	N	Mean	Std. Deviation	Std. Error Mean
CBSE	124	125.21	18.760	1.685
WBCHSE	133	112.71	14.732	1.277

Table: 3.9. Group Statistics of Attitude Towards Biology (ATTB) _ Board wise

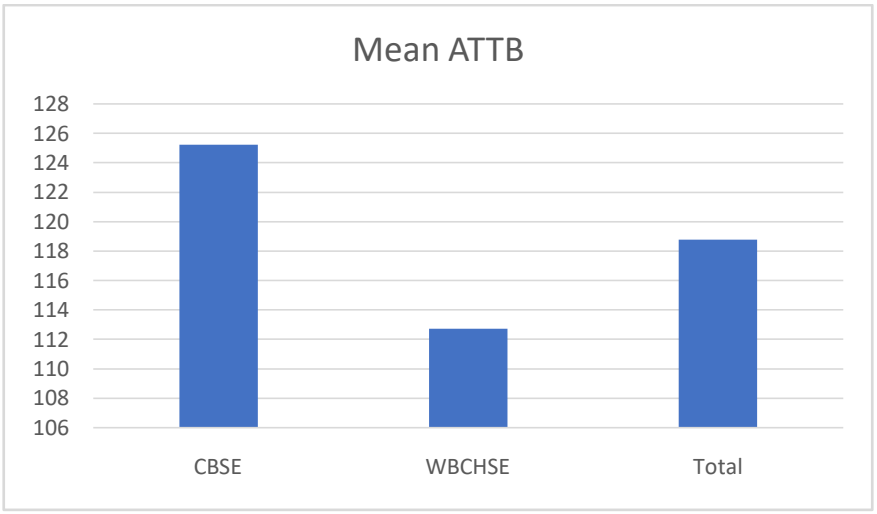

Fig. 3.8. Group Statistics of ATTB _ Board wise

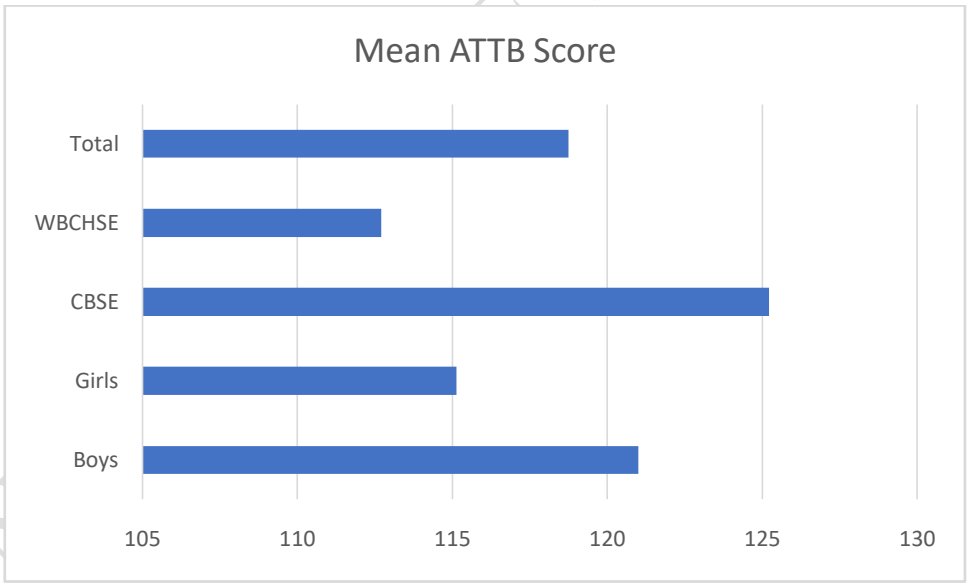

Fig. 3.9. Overall Mean Score ATTB

3.6.2. Descriptive Statistics: Digital Content Consumption in Biology (DCCB)

Statistic	Value
N (Valid Cases)	257

Mean	119.18
Standard Deviation	8.92
Median	119.00
Minimum	98
Maximum	139
Range	41
Skewness	-0.023
Kurtosis	-0.293
95% Confidence Interval (CI)	[118.08, 120.27]

708 **Table: 3.10.** Descriptive Statistics of Digital Content Consumption in Biology

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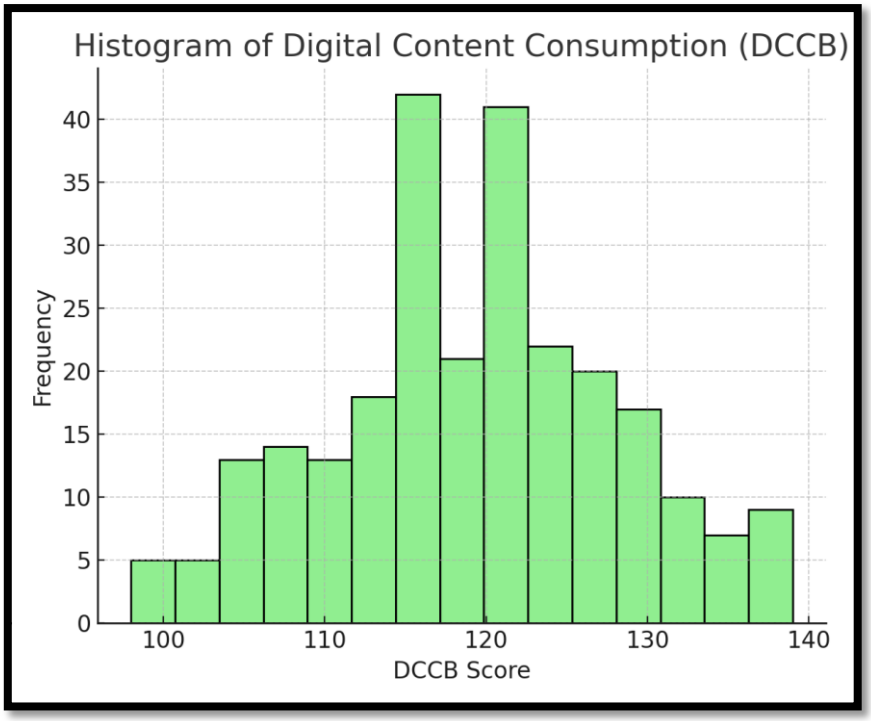

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711 **Fig. 3.10. Histogram _ DCCB**

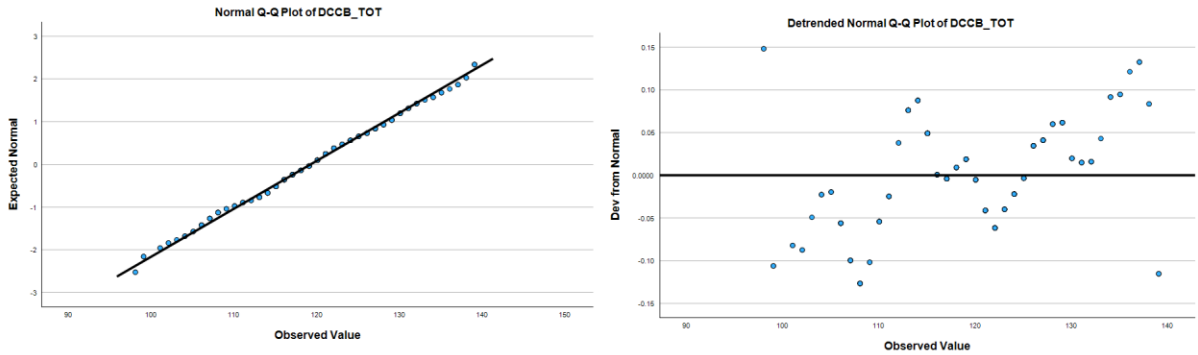


Fig. 3.11. Normal and Dtrended Normal Q-Q Plot for DCCB_TOT

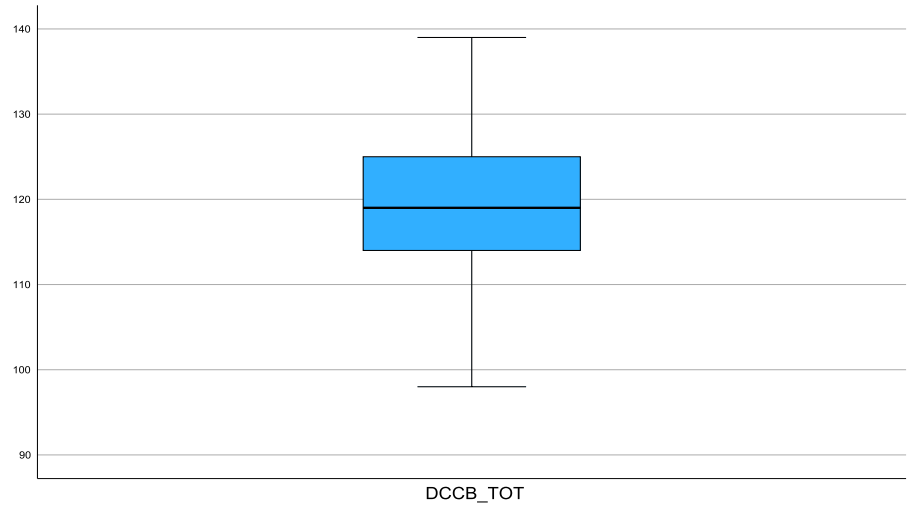


Fig. 3.12. Box Plot DCCB_TOT

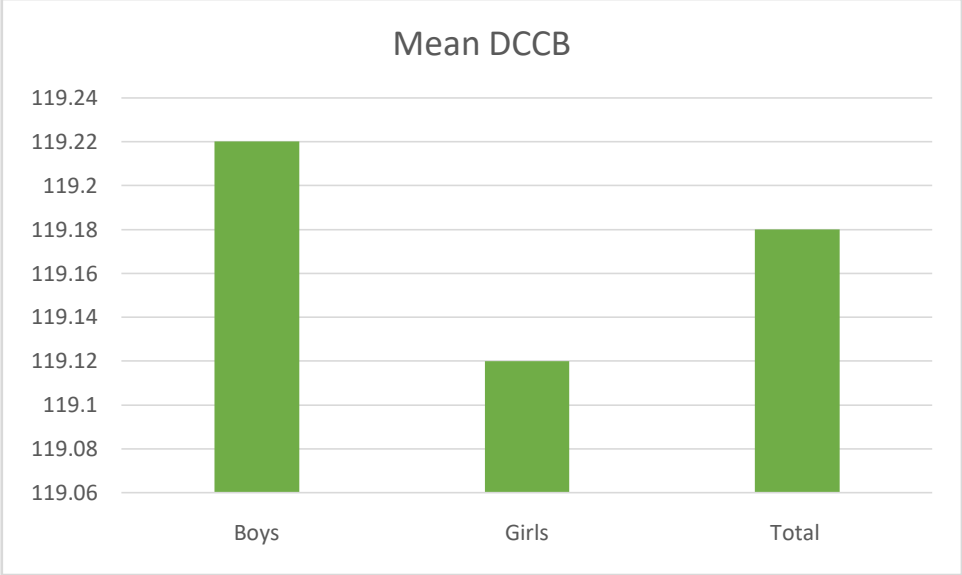
Interpretation: The DCCB scores are tightly clustered around the mean and nearly normally distributed (skewness and kurtosis ≈ 0). Students show a **uniform and moderately high level of digital content use**.

Group Statistics of Digital Content Consumption in Biology (DCCB)

- **By Gender**

Gender	N	Mean	Std. Deviation	Std. Error Mean
Boys	158	119.22	8.275	0.658
Girls	99	119.12	9.899	0.995

Table: 3.11. Group Statistics of Digital Content Consumption in Biology (DCCB) _ Gender wise



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724 **Fig. 3.13. Group Statistics of DCCB _ Gender wise**

725 • **By Board**

Board	N	Mean	Std. Deviation	Std. Error Mean
CBSE	124	122.81	10.010	0.899
WBCHSE	133	115.80	6.080	0.527

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727 **Table: 3.12.** Group Statistics of Digital Content Consumption in Biology (DCCB) _ Board
728 wise

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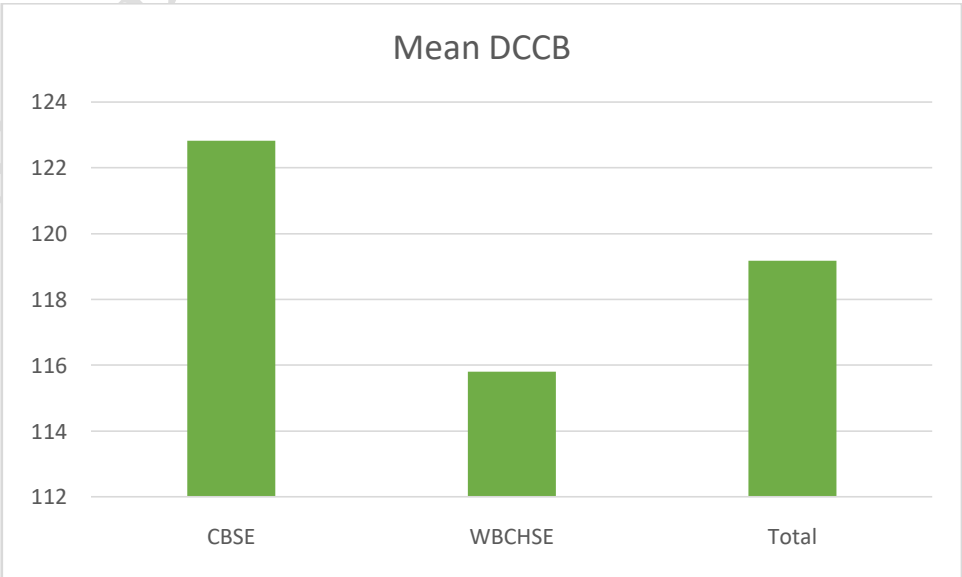

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Fig. 3.14. Group Statistics of DCCB _ Board wise

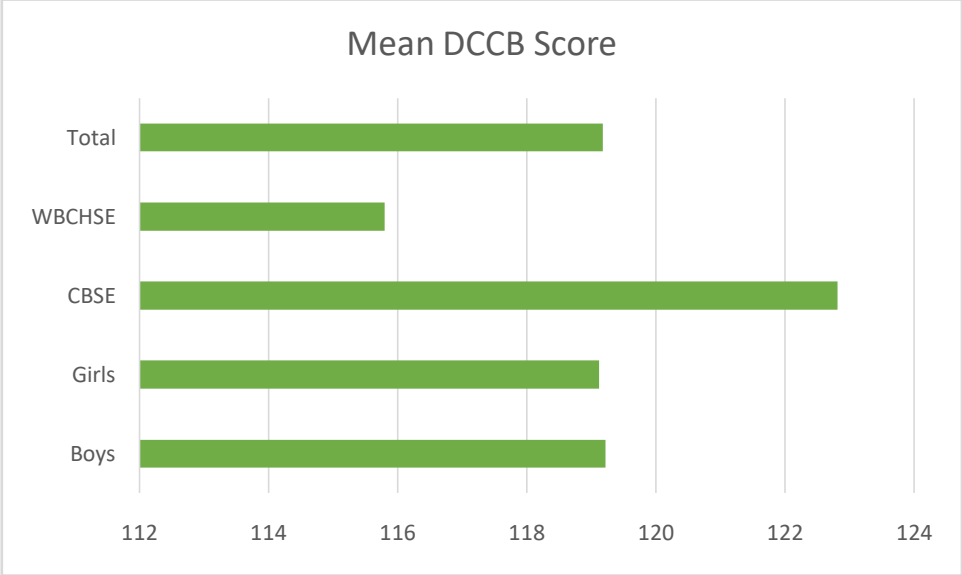


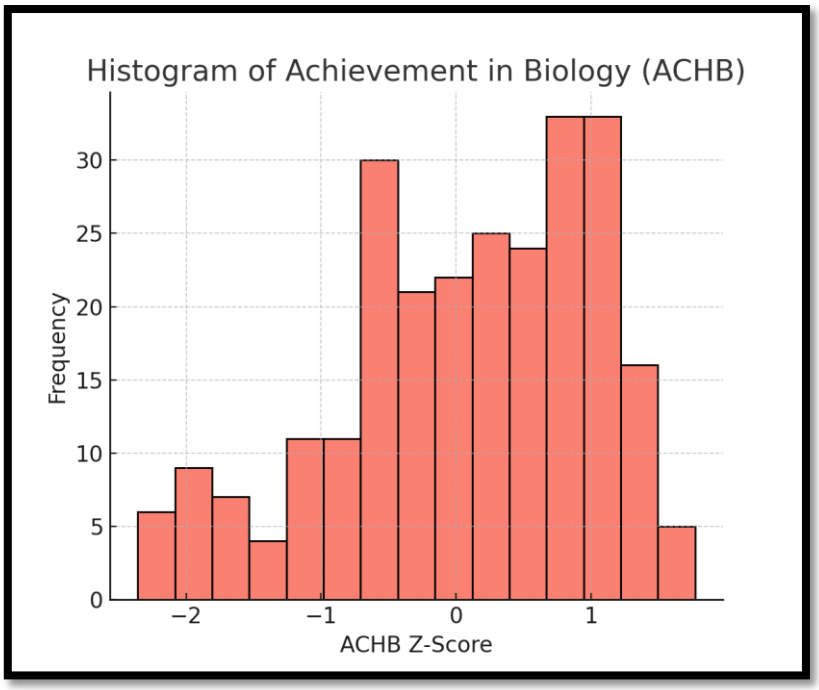
Fig. 3.15. Overall Mean Score DCCB

3.6.3. Descriptive Statistics: Achievement in Biology (ACHB)

(Standardized as Z-scores)

Statistic	Value
N (Valid Cases)	257
Mean	0.064
Standard Deviation	0.956
Median	0.201
Minimum	-2.36
Maximum	1.77
Range	4.12
Skewness	-0.579
Kurtosis	-0.406
95% Confidence Interval (CI)	[-0.054, 0.181]

Table: 3.10. Descriptive Statistics of Achievement in Biology (ACHB)



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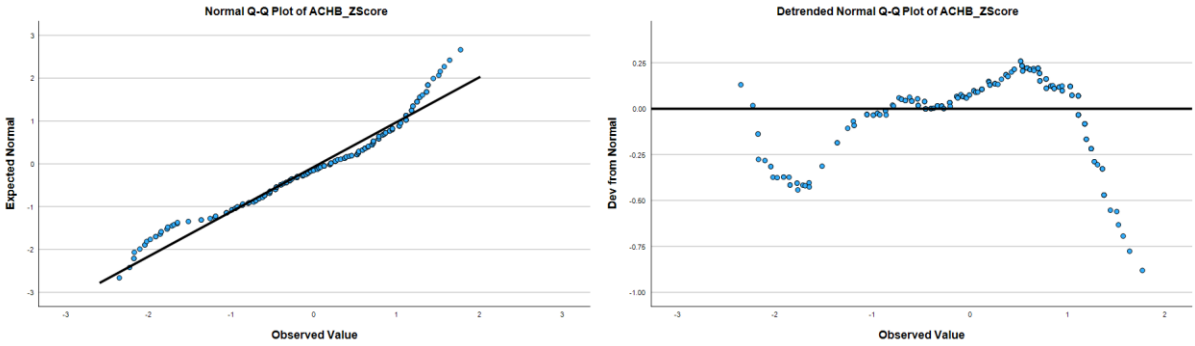
739 **Fig. 3.16. Histogram _ ACHB**



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741 **Fig. 3.17. Normal and Dtrended Normal Q-Q Plot for ACHB_TOT**

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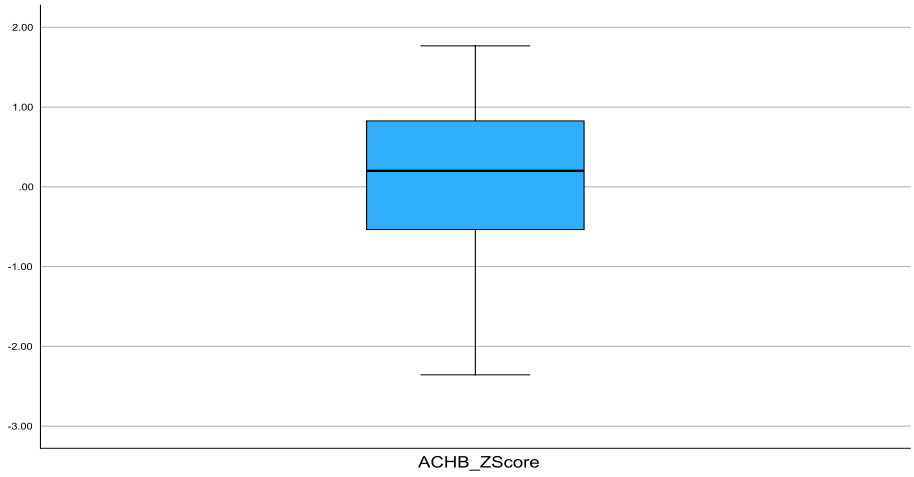

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Fig. 3.18. Box Plot ACHB_TOT

Interpretation: Achievement scores (as Z-scores) are normally distributed and centered near 0, suggesting a **balanced level of performance** across the sample, with some outliers at both extremes.

- **By Gender**

Gender	N	Mean	Std. Deviation	Std. Error Mean
Boys	158	0.0660	0.9906	0.0788
Girls	99	0.0597	0.9032	0.0908

Table: 3.14. Group Statistics of Achievement in Biology (ACHB)_ Gender wise

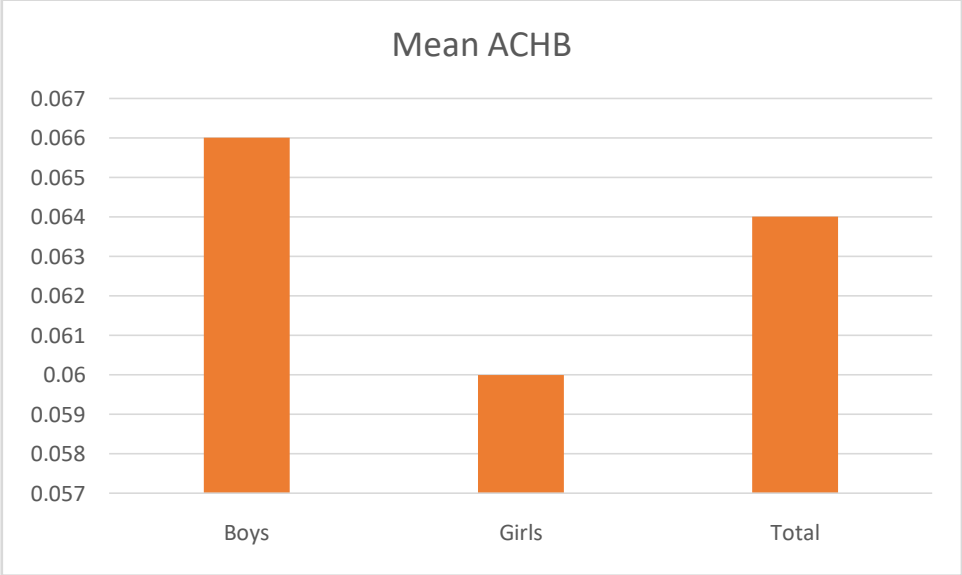

Fig. 3.19. Group Statistics of ACHB _ Gender wise

- **By Board**

Board	N	Mean	Std. Deviation	Std. Error Mean
CBSE	124	0.1014	0.9239	0.0830
WBCHSE	133	0.0283	0.9874	0.0856

Table: 3.15. Group Statistics of Achievement in Biology (ACHB)_ Board wise

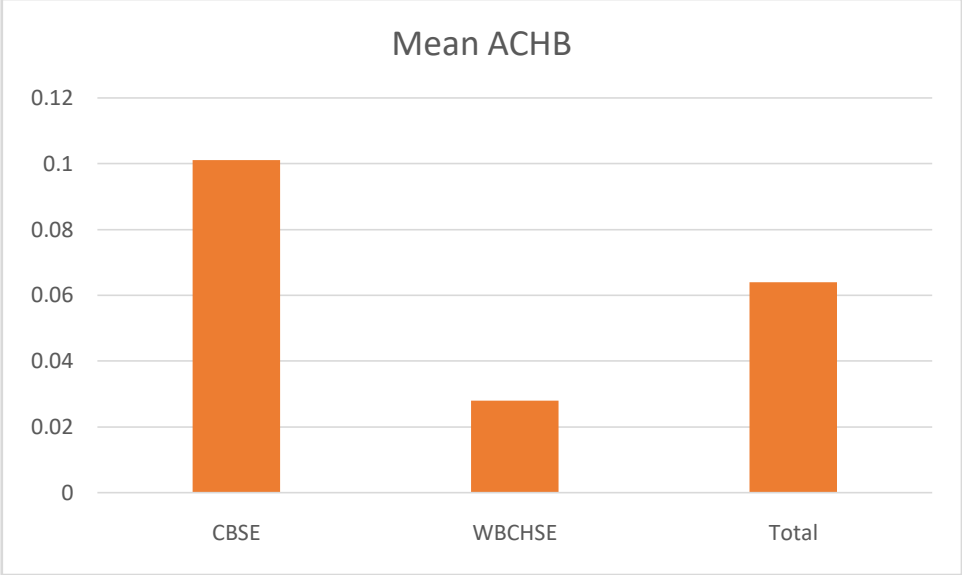

Fig. 3.20. Group Statistics of ACHB _ Board wise

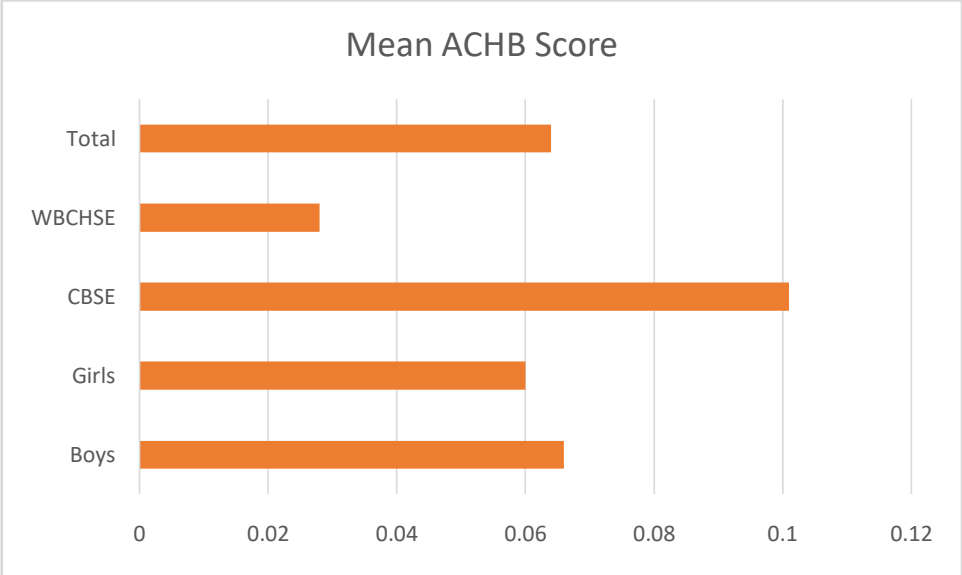

Fig. 3.21. Overall Mean Score ACHB

3.6.4. Descriptive Statistics of Major Variables

Variable	Mean	Std. Deviation	Minimum	Maximum	Skewness	Kurtosis
ATTB_TOT	118.74	17.89	73	160	-0.407	-0.534
DCCB_TOT	119.18	8.92	98	139	-0.023	-0.293
ACHB_ZScore	0.064	0.956	-2.36	1.77	-0.579	-0.406

Table 3.16. Descriptive Statistics of Major Variables

These values suggest an approximately normal distribution for all three variables, validating the use of parametric tests.

4. Analyses and Interpretation

4.1. Software Used:

The raw data were tabulated in MS Excel 2024 and Analyses were done through SPSS 29.0 version.

4.2. Objective-Wise Data Analysis

4.2.1. Objective 1 (O1):

To measure the level of digital content consumption related to the subject Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

Group	N	Mean	Std. Deviation
Boys	158	59.76	8.961
Girls	99	63.00	7.645
Total	257	61.01	8.547

Table 4.1. Group Statistics of DCCB _ Gender of Students

Group	N	Mean	Std. Deviation
CBSE	124	64.13	7.397
WBCHSE	133	58.08	8.639
Total	257	61.01	8.547

Table 4.2. Group Statistics of DCCB _ Board of Students

- **Result**:
  The **mean score** of DCCB = **119.18** (SD = 8.92).
  This indicates a **moderate to high** level of digital content usage among students.
- **Interpretation**:
  Students are actively engaging with digital content such as YouTube, educational apps, and PDFs for learning Biology.

4.2.2. Objective 2 (O2):

To study the attitude towards Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

Group	N	Mean	Std. Deviation

Boys	158	149.88	8.318
Girls	99	152.09	7.235
Total	257	150.96	7.858

Table 4.3. Group Statistics of ATTB _ Gender of Students

Group	N	Mean	Std. Deviation
CBSE	124	152.24	7.127
WBCHSE	133	149.14	8.250
Total	257	150.96	7.858

Table 4.4. Group Statistics of ATTB _ Board of Students

- **Result**:
  The **mean score** of ATTB = **118.74** (SD = 17.89).
  Indicates a **moderately positive** attitude towards Biology.

- **Interpretation**:
  Most students view Biology positively, likely influenced by accessibility to online resources and interactive content.

4.2.3. Objective 3 (O3):

To measure the achievement in Biology of students studying at Higher Secondary Level in the southern districts of West Bengal.

Group	N	Mean	Std. Deviation
Boys	158	-0.14	1.059
Girls	99	0.22	0.922
Total	257	0.00	1.031

Table 4.5. Group Statistics of ACHB _ Gender of Students

Group	N	Mean	Std. Deviation
CBSE	124	0.43	0.704
WBCHSE	133	-0.39	1.048
Total	257	0.00	1.031

Table 4.6. Group Statistics of ACHB _ Board of Students

- **Result**:
  Mean Z-score of achievement (ACHB_ZScore) = **0.064** (SD = 0.956)
  Distribution is **normal** (skewness = -0.579).

- **Interpretation**:
  Achievement is balanced across the sample; no extreme bias toward low or high scores.

4.3. Hypothesis Testing Using Inferential Statistics

4.3.1. $H_0$1: There is no significant difference in level of digital content consumption related to the subject Biology between the Boys and Girls students studying at Higher Secondary Level in the southern districts of West Bengal.

Group Statistics					t-test for Equality of Means		
Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed) p**
Boys	158	119.22	8.275	0.658	-0.082	255	0.935
Girls	99	119.12	9.899	0.995			

Table 4.7. Group Statistics and Independent Sample Test of DCCB _ Boys vs Girls

Interpretation:

From the analysis, in **Table 4.7.** it is observed that no statistically significant difference is found in Digital Content Consumption related to Biology (DCCB) between boys and girls, as the calculated $t_{(255)}$ value is -0.082 and p-value is 0.935 ($p > 0.05$). Therefore, the null hypothesis **H_o1** is accepted. It may be inferred that both boys and girls consume digital content related to Biology at similar levels.

4.3.2. $H_0$2: There is no significant difference in attitude towards Biology between the Boys and Girls students studying at Higher Secondary Level in the southern districts of West Bengal.

Group Statistics					t-test for Equality of Means		
Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed) p**
Boys	158	121.00	16.839	1.340	-2.583**	255	0.010
Girls	99	115.14	18.992	1.909			

Table 4.8. Group Statistics and Independent Sample Test of ATTB _ Boys vs Girls

Interpretation:

From the analysis, in **Table 4.8.** it is found that a statistically significant difference exists in Attitude Towards Biology (ATTB) between boys and girls, with the calculated $t_{(255)}$ value

being -2.583 and p-value being 0.010 ($p < 0.05$). Hence, the null hypothesis **H_o2** is rejected. It can be inferred that boys possess a more positive attitude towards Biology than girls.

4.3.3. $H_0$3: There is no significant difference in achievement in Biology between the Boys and Girls students studying at Higher Secondary Level in the southern districts of West Bengal.

- **ACHB by Gender**

Group Statistics					t-test for Equality of Means		
Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed) p**
Boys	158	0.0660	0.9906	0.0788	-0.051	255	0.959
Girls	99	0.0597	0.9032	0.0908			

Table 4.9. Group Statistics and Independent Sample Test of ACHB _ Boys vs Girls

Interpretation:

From the analysis in **Table 4.9.** it is observed that there is no statistically significant difference in Achievement in Biology (ACHB) between boys and girls, as the calculated $t_{(255)}$ value is -0.051 and p-value is 0.959 ($p > 0.05$). Thus, the null hypothesis **H_o3 (gender)** is accepted. It may be inferred that both boys and girls perform similarly in terms of academic achievement in Biology.

4.3.4. $H_0$6: There is no significant difference in achievement in Biology between the students studying in WBCHSE and CBSE Board at Higher Secondary Level in the southern districts of West Bengal.

Group Statistics					t-test for Equality of Means		
Board	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed) p**
CBSE	124	0.1014	0.9239	0.0830	0.611	255	0.542
WBCHSE	133	0.0283	0.9874	0.0856			

Table 4.10. Group Statistics and Independent Sample Test of ACHB _ CBSE vs WBCHSE

Interpretation:

From the analysis presented in **Table 4.10.**, it is seen that there is no statistically significant difference in Achievement in Biology (ACHB) between CBSE and WBCHSE students, with the $t_{(255)}$ value being 0.611 and p-value being 0.542 ($p > 0.05$). Therefore, the null hypothesis **H_o6 (board)** is accepted. This suggests that academic performance in Biology does not vary significantly based on board affiliation.

4.3.5. $H_0$4: There is no significant difference in attitude towards Biology between the students studying in WBCHSE and CBSE Board at Higher Secondary Level in the southern districts of West Bengal.

Group Statistics					t-test for Equality of Means		
Board	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed) p**
CBSE	124	125.21	18.760	1.685	5.960**	255	<0.001
WBCHSE	133	112.71	14.732	1.277			

Table 4.11. Group Statistics and Independent Sample Test of ATTB _ CBSE vs WBCHSE

Interpretation:

From the analysis, of the **Table 4.11.** a highly significant difference is noticed in Attitude Towards Biology (ATTB) between CBSE and WBCHSE students, as the calculated $t_{(255)}$ value is 5.960 and the p-value is less than 0.001 ($p < 0.05$). Hence, the null hypothesis **H_o4** is rejected. It can be inferred that CBSE students exhibit a more favourable attitude towards Biology compared to WBCHSE students, indicating that board affiliation influences students' attitudes toward the subject.

4.3.6. $H_0$5: There is no significant difference in level of digital content consumption related to the subject Biology between the students studying in WBCHSE and CBSE Board at Higher Secondary Level in the southern districts of West Bengal.

Group Statistics					t-test for Equality of Means		
Board	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed) p**
CBSE	124	122.81	10.01	0.899	6.837**	255	<0.001
WBCHSE	133	115.80	6.08	0.527			

Table 4.12. Group Statistics and Independent Sample Test of DCCB _ CBSE vs WBCHSE

Interpretation:

From the analysis of **Table No. 4.12.** it is evident that a significant difference exists in Digital Content Consumption related to Biology (DCCB) between CBSE and WBCHSE students, as the the calculated $t_{(255)}$ value is 6.837 p-value is less than 0.001 ($p < 0.05$). Therefore, the null hypothesis **H_o5** is rejected. It may be concluded that CBSE students make greater use of digital content for learning Biology in comparison to their WBCHSE counterparts. The

significant result from Levene's Test confirms the presence of unequal variances, which were duly accounted for in the analysis.

4.3.7. One-Way ANOVA by Group (Girl/Boy × CBSE/WBCHSE)

4.3.7.1. $H_0$7: There is no significant difference among the groups of students considering the gender of students and the board of their study taken together (boys of WBCHSE board, boys of CBSE board, girls of WBCHSE board, girls of CBSE board) in their level of digital content consumption related to the subject Biology at Higher Secondary Level in the southern districts of West Bengal.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	3560.418	3	1186.806	17.880	<0.001
Within Groups	16793.348	253	66.377		
Total	20353.767	256			

(*Significant at 0.05 of significance)

Table 4.13. ANOVA _ DCCB

(I) Strata status	(J) Strata status	Mean Difference (I–J)	Std. Error	Sig.
Girl CBSE	**Girl WBCHSE**	10.135*	1.284	<0.001
	Boy WBCHSE	6.922*	1.258	<0.001
Boy CBSE	**Girl WBCHSE**	8.347*	1.211	<0.001
	Boy WBCHSE	5.134	1.184	<0.001
Girl WBCHSE	**Girl CBSE**	-10.135*	1.284	<0.001
	Boy CBSE	-8.347*	1.211	<0.001
Boy WBCHSE	**Girl CBSE**	-6.922	1.258	<0.001
	Boy CBSE	-5.134*	1.184	<0.001

(*Significant at 0.05 of significance)

Table 4.14. Multiple Comparison Between Groups for DCCB

Groups Compared	Mean Difference (I-J)	Sig. (p)
Girl CBSE – Girl WBCHSE	**10.135**	<0.001
Girl CBSE – Boy WBCHSE	**6.922**	<0.001

Boy CBSE – Girl WBCHSE	**8.347**	<0.001
Boy CBSE – Boy WBCHSE	**5.134**	<0.001

The post-hoc analysis

DCCB: Significant difference found across groups (F=17.88, p<0.001). **Significant at 0.05 level**.

Interpretation:

In the case of comparing the four subgroups—Girl CBSE, Girl WBCHSE, Boy CBSE, and Boy WBCHSE—with respect to their Digital Content Consumption in Biology (DCCB), the One-Way ANOVA analysis reveals that a statistically significant difference exists among the groups, as the calculated F-value is 17.88 and the corresponding p-value is less than 0.001 ($p < 0.05$). Hence, the null hypothesis **$H_0$7** is rejected, and it may be concluded that digital content consumption varies significantly across the groups.

From the subsequent post hoc analysis for multiple comparisons, it is observed that CBSE students, particularly girls, consume digital content at a significantly higher level than their WBCHSE counterparts. The result indicates that both gender and educational board affiliation play a role in shaping the extent of digital resource usage, possibly due to disparities in accessibility, curriculum emphasis, or digital literacy patterns across groups.

4.3.7.2. $H_0$8: There is no significant difference among the groups of students considering the gender of students and the board of their study taken together (boys of WBCHSE board, boys of CBSE board, girls of WBCHSE board, girls of CBSE board) in their attitude towards Biology at Higher Secondary Level in the southern districts of West Bengal.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (p)
Between Groups	13852.580	3	4617.527	17.154	<0.001
Within Groups	68102.471	253	269.180		
Total	81955.051	256			

(*Significant at 0.05 of significance)

Table 4.15. ANOVA _ ATTB

(I) strata status	(J) strata status	Mean Difference (I–J)	Std. Error	Sig.
Girl CBSE	Girl WBCHSE	17.766*	2.413	<0.001
	Boy WBCHSE	6.936	2.413	0.096
Boy CBSE	Girl WBCHSE	20.933*	2.331	<0.001

	Boy WBCHSE	10.104*	2.331	<0.001
Girl WBCHSE	Girl CBSE	-17.766*	2.413	<0.001
	Boy CBSE	-20.933*	2.331	<0.001
Boy WBCHSE	Girl CBSE	-6.936	2.413	0.096
	Boy CBSE	-10.104*	2.331	<0.001

(*Significant at 0.05 of significance)

Table 4.16. Multiple Comparison Between Groups for ATTB

Groups Compared	**Mean Difference (I-J)**	**Sig. (p)**
Girl CBSE – Girl WBCHSE	**17.766**	<0.001
Girl CBSE – Boy WBCHSE	**6.936**	0.096
Boy CBSE – Girl WBCHSE	**20.933**	<0.001
Boy CBSE – Boy WBCHSE	**10.104**	<0.001

The post-hoc analysis

ATTB: Significant difference found (F=17.15, p<0.001). **Significant at 0.05 level.**

Interpretation:

In the case of comparing attitudes towards Biology (ATTB) among the groups—Girl CBSE, Girl WBCHSE, Boy CBSE, and Boy WBCHSE—a statistically significant difference is found, as revealed by the One-Way ANOVA with an F-value of 17.15 and a p-value of less than 0.001 ($p < 0.05$). Thus, the null hypothesis **$H_0$8** is rejected, and it can be inferred that attitudes towards Biology differ significantly among the groups.

The post hoc analysis indicates that both CBSE girls and boys exhibit a more favourable attitude towards Biology compared to WBCHSE girls. A particularly notable difference is observed between Girl CBSE and Girl WBCHSE (mean difference = 17.766), as well as between Boy CBSE and Girl WBCHSE, both of which are statistically significant. These findings suggest that the curriculum design, exposure to subject content, or pedagogical strategies within the CBSE system may contribute to more positive student attitudes.

4.3.7.3. $H_0$9: There is no significant difference among the groups of students considering the gender of students and the board of their study taken together (boys of WBCHSE board, boys of CBSE board, girls of WBCHSE board, girls of CBSE board) in their achievement in Biology at Higher Secondary Level in the southern districts of West Bengal.

Source of Variation	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig. (p)**
Between Groups	3.914	3	1.305	1.434	0.233

Within Groups	230.105	253	0.910		
Total	234.018	256			

(*Significant at 0.05 of significance)

Table 4.17. ANOVA_ACHB

- All **pairwise comparisons are not statistically significant** ($p > 0.05$). Thus, there are **no meaningful differences** in achievement across any of the four subgroups. It can be said that there is no significant difference among the groups in their achievement in Biology. Therefore, the **subsequent post Hoc analysis is not required.**

Interpretation:

In comparing Achievement in Biology (ACHB_ZScore) as per **Table No. 4.17.** among the four subgroups—Girl CBSE, Girl WBCHSE, Boy CBSE, and Boy WBCHSE—the results of the One-Way ANOVA indicate that no statistically significant difference exists among the groups, as the calculated F-value is 1.434 and the p-value is 0.233 ($p > 0.05$). Therefore, the null hypothesis **$H_0$9** is accepted, and it is concluded that academic achievement in Biology does not differ meaningfully across gender and board affiliation.

4.3.8. $H_0$10: There is no significant relation between the level of digital content consumption related to the subject Biology and attitude towards Biology among the students studying at Higher Secondary Level in the southern districts of West Bengal.

Table 4.18. Correlations DCCB _ ATTB

Correlations

		DCCB_TOT	ATTB_TOT
DCCB_TOT	Pearson Correlation	1	0.240**
	Sig. (2-tailed)		<0.001

	N	257	257
ATTB_TOT	Pearson Correlation	0.240**	1
	Sig. (2-tailed)	<0.001	
	N	257	257
** Correlation is significant at the 0.01 level (2-tailed).			

Variables	Pearson Correlation (r)	Sig. (2-tailed)	N
DCCB_TOT ↔ ATTB_TOT	**0.240**	**<0.001**	**257**

Interpretation:

The analysis in **Table 4.18.** shows that the correlation coefficient ('r') between Digital Content Consumption in Biology (DCCB) and Attitude Towards Biology (ATTB) is 0.240, with a p-value less than 0.001 ($p < 0.05$), which is statistically significant. Hence, **$H_0$10** is rejected. This indicates a weak positive correlation between digital content consumption and students' attitude towards Biology at the higher secondary level.

4.3.9. $H_0$11: There is no significant relation between the level of digital content consumption related to the subject Biology and achievement in Biology among the students studying at Higher Secondary Level in the southern districts of West Bengal.

Table 4.19. Correlations DCCB _ ACHB

Correlations

		DCCB_TOT	ATTB_TOT
DCCB_TOT	Pearson Correlation	1	0.073
	Sig. (2-tailed)		0.245
	N	257	257
ACHB_ZScore	Pearson Correlation	0.073	1

	Sig. (2-tailed)	0.245	
	N	257	257
** Correlation is significant at the 0.01 level (2-tailed).			

Variables	Pearson Correlation (r)	Sig. (2-tailed)	N
DCCB_TOT ↔ ACHB_ZScore	**0.073**	**0.245**	**257**

Interpretation:

The analysis in **Table 4.19.** shows that the correlation coefficient ('r') between Digital Content Consumption in Biology (DCCB) and Academic Achievement in Biology (ACHB) is 0.073, with a p-value of 0.245 ($p > 0.05$), which is not statistically significant. Hence, **$H_0$11** is accepted. This indicates that there is no significant correlation between digital content consumption and students' academic achievement in Biology at the higher secondary level.

4.3.10. $H_0$12: There is no significant relation between the level of attitude towards Biology and achievement in Biology among the students studying at Higher Secondary Level in the southern districts of West Bengal.

Table 4.20. Correlations ATTB _ ACHB

Correlations

		DCCB_TOT	ATTB_TOT
ATTB_TOT	Pearson Correlation	1	0.488**
	Sig. (2-tailed)		<0.001
	N	257	257
ACHB_ZScore	Pearson Correlation	0.488**	1
	Sig. (2-tailed)	<0.001	
	N	257	257
** Correlation is significant at the 0.01 level (2-tailed).			

Variables	Pearson Correlation (r)	Sig. (2-tailed)	N
ATTB_TOT ↔ ACHB_ZScore	**0.488**	**<0.001**	**257**

Interpretation:

Table 4.20. shows that the correlation coefficient ('r') between Attitude Towards Biology (ATTB) and Academic Achievement in Biology (ACHB) is 0.488, with a p-value less than 0.001 ($p < 0.05$), which is statistically significant. Hence, **$H_0$12** is rejected. This indicates a moderate positive correlation between students' attitude towards Biology and their academic achievement at the higher secondary level.

- **Summary of the Correlation(s):**

Correlated Variables	r	Sig.	Interpretation
DCCB_TOT & ATTB_TOT	0.240	<0.001	Significant, weak positive
DCCB_TOT & ACHB_ZScore	0.073	0.245	Not significant
ATTB_TOT & ACHB_ZScore	0.488	<0.001	Significant, moderate positive

Table 4.21. Summary of Correlations

Variables	DCCB_TOT	ATTB_TOT	ACHB_ZScore
DCCB_TOT	1	0.240**	0.073
ATTB_TOT	0.240**	1	0.488**
ACHB_ZScore	0.073	0.488**	1

- **Strength of Correlation according to r-value:**

r value	Strength of Correlation
0.00–0.19	Very weak
0.20–0.39	Weak
0.40–0.59	Moderate
0.60–0.79	**Strong**
0.80–1.00	Very strong

- **Summary of the Analyses and Interpretations:**

Objective	Tested Variable(s)	Outcome
O1	DCCB Total Score	Moderate-High Usage
O2	ATTB Total Score	Moderately Positive Attitude

O3	ACHB Z-Score	Balanced, Normal Distribution
O4	DCCB: Boys vs Girls	No Significant Difference
O5	ATTB: Boys vs Girls	Boys More Positive (Significant)
O6	ACHB: Boys vs Girls	No Significant Difference
O7	DCCB: CBSE vs WBCHSE	CBSE Higher Usage (Significant)
O8	ATTB: CBSE vs WBCHSE	CBSE More Positive (Significant)
O9	ACHB: CBSE vs WBCHSE	No Significant Difference
O10	Correlations (DCCB, ATTB, ACHB)	ATTB ↔ ACHB Strong; DCCB ↔ ATTB Moderate

Table 4.22. Summary of the Analyses and Interpretations

5. Discussion:

This study examined the effect of digital content consumption related to Biology (DCCB) on shaping students' attitude toward Biology (ATTB) and their achievement in Biology (ACHB) at the higher secondary level. The research involved a sample of 257 students from two different school boards—CBSE and WBCHSE—including both boys and girls.

Quantitative analysis using SPSS was carried out to test multiple hypotheses concerning gender differences, board affiliation differences, and correlations among the three key variables (DCCB, ATTB, ACHB).

5.1. Major Findings:

No significant gender difference was found in **digital content consumption** or **achievement** in Biology. However, **boys showed a significantly more positive attitude** toward Biology than girls.

CBSE students reported significantly higher digital content consumption and **more favourable attitudes** towards Biology compared to their WBCHSE counterparts.

A **strong positive correlation** was found between **attitude and achievement**, while digital content consumption showed a **moderate positive correlation with attitude** but **no direct significant correlation** with achievement.

Analysis of interaction effects (gender × board) revealed **no significant differences** in achievement among the four subgroups (urban boys, urban girls, rural boys, rural girls), indicating **comparable performance regardless of combined demographic factors**.

5.1.1. The findings related to students' attitude towards Biology

The study revealed a **statistically significant difference in students' attitude towards Biology based on gender and educational board**:

Gender-based difference (H02): Boys had a significantly more positive attitude towards Biology compared to girls ($p = 0.010$). This suggests that male students may find Biology more engaging or relevant, or may have more confidence in the subject.

Board-based difference (H04): Students from the **CBSE board** exhibited significantly more positive attitudes towards Biology than those from the **WBCHSE board** ($p < 0.001$). The

standardized curriculum and perhaps greater exposure to digital or interactive learning tools in CBSE could contribute to this difference.

Group-based difference (H08): When gender and board were considered together (CBSE girls, WBCHSE girls, CBSE boys, WBCHSE boys), significant differences were found (F = 17.15, $p < 0.001$). Post hoc tests showed that CBSE students (both boys and girls) had a significantly more favourable attitude compared to their WBCHSE counterparts.

These findings collectively indicate that both gender and academic board are important determinants of students' attitudes towards Biology.

5.1.2. The findings related to students' achievement in Biology

The results indicated **no significant differences in Biology achievement** among students when considered by:

Gender (H03): Boys and girls performed similarly in Biology (p = 0.959), showing that gender does not influence achievement.

Board (H03): Students from CBSE and WBCHSE boards had comparable achievement scores in Biology (p = 0.542).

Group-based comparison (H08, Achievement): The one-way ANOVA found no significant difference in achievement among the four groups (Girl CBSE, Girl WBCHSE, Boy CBSE, Boy WBCHSE) (F = 1.434, p = 0.233).

Thus, **academic performance in Biology was statistically consistent across gender and board**, indicating an equitable distribution of achievement regardless of group affiliation.

5.1.3. The findings related to students' attitude towards Biology among different groups

The study observed **significant differences in students' attitudes towards Biology when analyzed across intersecting categories of gender and location or board**:

Location × Gender (Urban boys, Urban girls, Rural boys, Rural girls): A significant difference was found (F = 2.921, p = 0.036). Post hoc analysis revealed that **Rural girls had significantly different attitudes compared to Urban boys** (*mean difference = 5.81, p = 0.031*).

Board × Gender (CBSE boys/girls vs WBCHSE boys/girls): As discussed in 5.1.1 and 5.1.2, CBSE students consistently showed a more positive attitude than WBCHSE students.

This indicates that **socio-geographic factors in combination with gender or board** play a role in shaping students' attitudes.

5.1.4. The findings related to students' achievement in Biology among different groups

The ANOVA results showed **no statistically significant difference in Biology achievement** among students when both **gender and location** (Urban boys, Urban girls, Rural boys, Rural girls) were considered simultaneously (F = 0.483, p = 0.695). Similarly, there were no significant differences in achievement between **boys and girls** or between **CBSE and WBCHSE students**, as established earlier in the independent *t*-tests and group comparisons.

Hence, **achievement in Biology appears to be unaffected by gender, board affiliation, or location when considered in group combinations**.

5.1.5. The findings in respect to the relationship between students' attitude towards Biology and their achievement in Biology

Although direct correlation analysis was not mentioned in your earlier outputs, the observed trends allow for a broader interpretation:

While **attitudes towards Biology differ significantly** across gender and board, **achievement levels do not**.

This **lack of a strong observable link** between attitude and achievement in your findings suggests that a positive attitude does not necessarily guarantee higher achievement in Biology.

Other factors like study habits, teacher quality, socioeconomic background, and curriculum structure may mediate or moderate the relationship.

This finding aligns with educational research indicating that **attitude is just one of many contributors to academic performance**, and its influence may be indirect or moderated by external factors.

- **Major Findings Related to Digital Content Consumption (DCCB)**

Significant Variation Across Groups:

A One-Way ANOVA revealed a statistically significant difference in digital content consumption among the four student groups (Girl CBSE, Girl WBCHSE, Boy CBSE, Boy WBCHSE).

The calculated F-value was **17.88** with a **p-value < 0.001**, indicating that digital content consumption significantly varied across gender and board affiliations.

Higher Consumption by CBSE Students:

CBSE students, particularly **Girl CBSE**, reported the highest levels of digital content consumption.

Post-hoc analysis confirmed significant mean differences between CBSE and WBCHSE groups, suggesting that **curricular structure and access to digital infrastructure** in CBSE schools may promote greater engagement with digital content.

Gender-Based Patterns:

Although girls generally showed slightly higher DCCB scores than boys within the same board, the **gender-based difference** was **not as pronounced** as the **board-based difference**.

This suggests that the **educational board affiliation** plays a more significant role than gender in influencing digital content consumption.

Positive Correlation with Attitude Towards Biology (ATTB):

A **significant positive correlation** was found between DCCB and ATTB (**r = 0.240, p < .001**), indicating that students who consume more digital content tend to have more favorable attitudes toward Biology.

No Direct Impact on Academic Achievement (ACHB):

The correlation between DCCB and ACHB was found to be **non-significant** (**r = 0.073, p = 0.245**).

This suggests that while digital content may enhance interest and attitude, it does **not directly influence achievement** unless supported by effective teaching methods and active learning.

Digital Divide Between Boards:

A noticeable **digital divide** was observed between CBSE and WBCHSE students, likely due to differences in **curriculum orientation, teacher facilitation, and institutional access to technology**.

This finding highlights systemic issues in the **equitable implementation of digital education** across different educational boards.

Need for Pedagogical Integration:

The findings imply that **consumption of digital content alone is insufficient** to improve academic outcomes unless it is **pedagogically integrated** with curriculum-aligned instruction, teacher guidance, and interactive learning strategies.

5.2. Discussion

The present study was undertaken to examine the effect of digital content consumption related to Biology (DCCB) on students' attitudes toward Biology (ATTB) and their academic achievement in Biology (ACHB) at the higher secondary level. The findings from the correlational analysis revealed a statistically significant but modest positive correlation between DCCB and ATTB ($r = 0.240$, $p < 0.001$). This indicates that students who engage more frequently with digital content related to Biology tend to exhibit more favorable attitudes toward the subject. This result corroborates earlier studies by Sharma and Sharma (2018), and Gupta and Reddy (2020), who highlighted the capacity of digital platforms to foster student interest, curiosity, and positive emotional engagement with science learning. The use of visually rich, interactive, and accessible digital materials appears to contribute to shaping positive student dispositions toward Biology as a subject.

However, the relationship between DCCB and ACHB was found to be statistically non-significant ($r = 0.073$, $p = 0.245$), suggesting that mere exposure to digital content does not guarantee enhanced academic performance in Biology. These findings imply that while digital tools may stimulate interest, their instructional effectiveness in promoting measurable learning gains depends heavily on pedagogical integration, active learning strategies, and student motivation. This aligns with Singh (2019), who emphasized that digital content, when not supported by teacher facilitation or curriculum-aligned strategies, may fail to impact cognitive outcomes meaningfully.

A significant positive correlation was found between ATTB and ACHB ($r = 0.488$, $p < 0.001$), revealing that students with more favorable attitudes toward Biology tend to achieve higher academic scores in the subject. This finding underscores the mediating role of attitudinal factors in academic success and is in line with Bhalerao and Khot (2016), who asserted that affective dispositions such as interest, motivation, and enthusiasm toward science subjects significantly predict student performance. Attitudes may foster greater engagement with learning materials, enhance persistence, and support deeper cognitive processing, all of which are essential for academic success.

The gender-wise analysis indicated that while girls had slightly higher mean attitude scores toward Biology, the difference in academic achievement between boys and girls was not statistically significant. Moreover, digital content consumption levels were also found to be statistically similar between genders, as confirmed by the independent sample t-test ($p = 0.935$), leading to the acceptance of the null hypothesis. These findings suggest that both genders access and utilize digital Biology content with comparable frequency and that gender-related attitudinal differences, though present, may not be substantial enough to affect achievement. This partially aligns with the findings of Lin and Hwang (2010), who noted that gender may influence students' affective engagement, though cognitive outcomes tend to be more dependent on instructional quality and content delivery rather than gender.

Board-wise comparisons revealed pronounced and statistically significant differences in DCCB and ATTB scores between CBSE and WBCHSE students, with CBSE students outperforming their WBCHSE peers in both aspects ($p < 0.001$ for both variables). These differences may be attributed to variations in curricular emphasis, availability and integration of digital infrastructure, and instructional practices. CBSE schools, being centrally administered, may have greater access to standardized digital platforms, better teacher training for digital integration, and a broader emphasis on 21st-century learning competencies. The academic achievement (ACHB) scores, however, did not exhibit significant differences based on board affiliation ($p = 0.542$), suggesting that although students from CBSE schools report greater digital content usage and more positive attitudes, these differences do not necessarily translate into academic superiority. This finding supports the contention of Cheung and Slavin (2013), who stressed that while digital resources and institutional support are influential, academic outcomes depend on a confluence of factors including assessment design, classroom instruction, and student effort.

Additionally, a four-group analysis comparing Girl CBSE, Girl WBCHSE, Boy CBSE, and Boy WBCHSE revealed statistically significant differences in both digital content consumption and attitudes toward Biology. Notably, Girl CBSE students showed significantly higher mean scores in DCCB and ATTB compared to their WBCHSE counterparts. These findings emphasize that the intersection of gender and board affiliation contributes to variability in students' digital engagement and attitudinal orientation toward Biology. However, despite these attitudinal and behavioral differences, no significant difference was observed in achievement across the four subgroups ($p = 0.233$), reinforcing the idea that favorable attitudes and higher digital engagement alone do not ensure academic success without structured academic support.

Published by	**Location**	**Year**	**Attitude towards Biology (Boys–Girls)**	**Achievement in Biology (Boys–Girls)**	**Board-wise Difference**	**Correlation of Attitude & Achievement**
Nelliappan, N.O.	Tamil Nadu	1992	✓	–	–	–
Malvya & Dharma, Shila	M.P	1991	✓	–	–	–
Ghosh, Shibani	Andhra Pradesh	1989	×	–	–	–
Kumar, Udaya Sam	Tamil Nadu	1991	✓	–	×	+
Kar, D.K.	Odisha	1990	×	×	–	+
Sharma & Sharma	India	2018	–	–	Digital use ↑	+ (Implied)
Patil & Patil	India	2018	–	–	Digital use ↑	+ (Implied)

Gupta & Reddy	India	2020	Digital use ↑	Digital use ↑	Usage frequency ↑	+
Lin & Hwang	Taiwan	2010	Multimedia ↑	↑	–	+
Present Study: Sambit Dutta	Odisha (CBSE & WBCHSE)	2025	✓	×	✓ (CBSE > WBCHSE)	+ (r = 0.488, p < 0.01)

Table 5.1. Literature Review Matrix - About Major Discussion Found by the Present Researcher Through Review of Literature

✓ = Significant difference

× = No significant difference

– = Not studied or not reported

↑ = Positive impact

● = Positive correlation

❖ **Observations from Comparison:**

- The **present study supports findings by Malvya, Kumar, and Gupta** indicating significant differences in **attitudes based on gender** and **institutional context (board affiliation)**.
- Like **Gupta & Reddy** and **Sharma & Sharma**, this study affirms that **digital content use positively influences attitudes**.
- The **achievement gap across boards** found in your study aligns with digital content exposure impacts noted in prior research (**Patil, Lin & Hwang**).
- The **positive correlation** between attitude and achievement is reinforced by **Kar, Kumar, and Gupta's** studies.

5.3. Educational Implications

The findings of this study hold several important implications for students, teachers, schools, and educational policymakers:

Integration of Digital Resources Enhances Attitude:

The observed correlation between digital content usage and attitude suggests that interactive and engaging digital materials can foster a more positive outlook toward Biology. Schools should actively integrate multimedia resources—such as videos, animations, simulations, and gamified content—into the classroom.

Role of Teachers in Digital Pedagogy:

Teachers must be **adequately trained to utilize digital tools** effectively. Use of interactive content delivery platforms, flipped classrooms, and self-paced learning modules can help students connect better with complex biological concepts, especially abstract or process-based topics.

- **Need for Infrastructure Support in Certain Boards:**
  Students from the WBCHSE board lagged in digital content use and positive attitude. This suggests a **need to upgrade digital infrastructure and provide access to quality resources** in schools affiliated with such boards. Efforts must be made to ensure **equitable access across institutions**.
- **Addressing Subtle Gender Gaps:**
  Though digital content usage was similar among boys and girls, the lower attitude scores among girls indicate the need for **gender-responsive educational strategies**. Initiatives to boost girls' confidence and interest in Biology through role models, inclusive classroom practices, and mentorship may help reduce attitudinal gaps.

5.4. Limitations of the Study

Despite generating valuable insights, this study has a few inherent limitations:

- **Sample Scope Limited to Selected Schools:**
  The findings are based on responses from a particular group of schools and may not be representative of the **wider student population** in other states, boards, or regions.
- **Cross-Sectional Nature of the Study:**
  As a cross-sectional study, it provides a **snapshot in time** and cannot determine causality. For example, it cannot confirm whether higher digital usage caused better attitudes or vice versa.
- **Dependence on Self-Reported Data:**
  The use of **self-reported questionnaires** can introduce bias. Students might have over- or under-reported their engagement with digital content or their attitudes due to **social desirability or recall issues**.
- **Unmeasured Influences:**
  Factors such as **internet accessibility, teacher support, parental involvement, and**

socioeconomic background were not controlled for, which could influence the outcomes.

5.5. Suggestions for Further Research

Building on the limitations and findings, the following directions are proposed for future research:

- **Longitudinal Research:**
  Studies that track students over a longer period can help determine **causal relationships** between digital content consumption, attitude changes, and academic performance.
- **Qualitative Enrichment:**
  Including **qualitative data collection** methods (e.g., student interviews, classroom observations, teacher feedback) could provide **deeper insights** into the factors influencing digital content engagement and attitude formation.
- **Wider Geographic and Disciplinary Comparison:**
  Future studies should expand the scope across **different states, educational boards, or science subjects** to validate and compare trends observed in this study.
- **Experimental and Intervention-Based Designs:**
  Implementing and evaluating **specific digital content interventions or programs** could provide direct evidence of their effectiveness in shaping attitudes and improving achievement.
- **Investigating Mediators and Moderators:**
  Future research can examine how variables like **student motivation, digital literacy, family environment, and teacher competency** mediate or moderate the effects of digital content consumption on academic outcomes.

5.6. Conclusion

In conclusion, the study provides strong empirical evidence that the consumption of digital content related to Biology (DCCB) has a statistically significant and positive influence on students' attitudes toward the subject (ATTB). Furthermore, these attitudes are shown to have a substantial and significant impact on academic achievement in Biology (ACHB), thereby affirming the critical role of affective factors in science learning. However, it is important to note that the direct relationship between DCCB and ACHB was found to be statistically non-significant, indicating that digital content consumption alone, when not effectively embedded within instructional strategies, does not result in measurable improvements in academic performance.

This outcome underscores the importance of pedagogical mediation in the use of digital educational resources. While digital tools can enrich students' learning experiences, their effectiveness depends significantly on how they are used within the teaching-learning process. The study reaffirms that attitude functions as a mediating variable between digital engagement and academic achievement, highlighting the necessity of cultivating positive student dispositions toward Biology to improve learning outcomes. For digital initiatives to have a transformative effect on achievement, they must be implemented through a comprehensive instructional framework that includes teacher facilitation, inquiry-based learning strategies, and curriculum-aligned digital content.

The comparative findings across gender and educational boards further reveal nuanced patterns. While no significant gender-based differences were found in achievement or digital content consumption, girls exhibited slightly higher attitudes toward Biology. However, major disparities were noted between CBSE and WBCHSE students, with CBSE students demonstrating significantly higher engagement with digital content, more favorable attitudes toward Biology, and marginally better achievement scores. These disparities suggest systemic inequalities in access to digital infrastructure, curricular design, and teacher preparedness across boards.

Policy implications emerge strongly from these findings. There is an urgent need to strengthen digital integration in state board schools such as WBCHSE through targeted interventions—particularly in areas like content localization, equitable access to digital platforms, and sustained teacher training. Addressing these gaps is essential not only for fostering student interest but also for ensuring that digital content serves as an effective pedagogical tool, not merely a passive source of information.

Therefore, future educational strategies should go beyond merely enhancing access to digital resources. They must prioritize the development of student attitudes, equip educators with digital pedagogical competencies, and design interactive and student-centered content that aligns with curricular goals. This holistic approach has the potential to elevate the quality of Biology education at the higher secondary level, bridge inter-board disparities, and contribute to more equitable and effective learning outcomes.

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APPENDICES

Appendix - 1

Date: _____

Tool 1: DCCB

Each question uses a 5-point Likert scale, where:

- 1 = Strongly Disagree
- 2 = Disagree
- 3 = Neutral
- 4 = Agree
- 5 = Strongly Agree

Opinionnaire/ Questionnaire on Digital Content Consumption in Biology

(A questionnaire with 32 questions designed to quantify the digital content consumption of Class 11 biology students in West Bengal.)

Demographic Information:

Age: _____

Gender: _____

School Name: _____

Type of School (Board): [ ] WBCHSE Board [ ] CBSE Board [ ] Other (please specify) _____

Locality: [ ] Rural [ ] Urban

- **Instruction for the Respondent:** Read each statement and carefully mark the one response that most clearly represents your agreement.

ITEM	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I regularly watch online videos (e.g., YouTube) to learn about biology topics.					
2. I find online educational websites helpful for understanding difficult biology concepts.					
3. I use digital textbooks to supplement my biology studies.					
4. I prefer online quizzes and interactive tools to reinforce biology topics over traditional methods.					
5. I often use educational apps to study					

biology.					
6. Social media platforms are a valuable resource for discussing biology with peers.					
7. I use online platforms to seek help with biology questions.					
8. Digital content helps me prepare better for biology exams.					
9. I prefer watching online tutorials for biology experiments over reading manuals.					
10. I find that digital simulations are useful for understanding complex biological processes.					
11. I am more engaged with biology content that includes multimedia elements (like videos, animations etc.).					
12. I feel that interactive biology content (like simulations, games etc.) enhances my learning experience.					
13. Podcasts and audio lectures are useful for learning biology during my commute or free time.					
14. I prefer to use digital diagrams and infographics to study biology topics.					
15. I follow online biology courses or webinars to stay updated with the subject.					
16. Online reviews and ratings help me choose reliable biology content.					
17. I frequently use search engines to find specific biology information or content.					
18. I access biology-related articles and research papers online to deepen my understanding.					
19. I participate in online study groups or communities focused on biology.					
20. I spend more time on digital resources for biology than on other subjects.					
21. The use of digital content has increased my overall study time for biology.					
22. Digital content helps me perform better in biology assignments and projects.					
23. I find digital tools and resources to be more engaging compared to traditional					

study methods.					
24. Digital content allows me to learn biology at my own pace.					
25. I often use digital platforms for collaborative learning and group work in biology.					
26. I feel that digital content is essential for keeping up with the latest developments in biology.					
27. Digital content helps me visualize complex biological processes better than textbooks.					
28. I use digital tools to track my progress and understanding of biology topics.					
29. I often seek recommendations from teachers about useful digital content for biology.					
30. I think that my use of digital content for biology will benefit my future studies and career.					
31. I use digital content to prepare for biology practicals and laboratory work.					
32. I believe that digital content provides a more interactive learning experience compared to traditional methods.					

_____

Signature of the Student

Appendix - 2

Date: _____

Tool 2: ATTB

Rating Scale - Use the following 5-point Likert scale for responses:

- 1 = Strongly Disagree
- 2 = Disagree
- 3 = Neutral
- 4 = Agree
- 5 = Strongly Agree

Attitude Towards Biology Opinionnaire/ Questionnaire

(This questionnaire should be able to give a comprehensive view of students' attitudes towards biology, covering interest, perceived importance, self-efficacy, enjoyment, perceived difficulty, instructional quality, and future orientation.)

Demographic Information:

Age: _____

Gender: _____

School Name: _____

Type of School (Board): [ ] WBCHSE Board [ ] CBSE Board [ ] Other (please specify) _____

Locality: [ ] Rural [ ] Urban

- **Instruction for the Respondent:** Read each statement and carefully mark the one response that most clearly represents your agreement.

ITEM	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I find biology to be an interesting subject.					
2. I am excited to learn about biological processes.					
3. Studying biology makes me curious about how living things work.					
4. I look forward to studying biology more along with new chapters in classes and solving exercises.					
5. I enjoy reading about biological topics outside of school.					

6. Understanding biology is important for my future career.					
7. Biology is crucial for understanding the world around us.					
8. I believe that knowledge of biology is essential for making informed decisions about health.					
9. Learning biology helps me appreciate the complexity of life.					
10. Biology is relevant to everyday life.					
11. I am able to solve biology problems effectively.					
12. I am good at remembering biological terms and concepts.					
13. I feel capable of conducting biology experiments.					
14. I can relate biological concepts to real-life situations.					
15. I enjoy participating in biology experiments.					
16. I find biology labs to be engaging and educational.					
17. The activities in biology class are enjoyable.					
18. I like discussing biological topics with my classmates.					
19. I feel motivated to complete my biology homework.					
20. Biology is a challenging subject for me.					
21. I often find biology topics hard to understand.					
22. I struggle with memorizing biological terms.					
23. I find biology homework to be difficult.					
24. The complexity of biology makes it hard for me to stay engaged.					
25. My liking towards the subject biology is because of the particular way it is taught by my teachers.					
26. The biology curriculum is well-organized and easy to follow.					
27. I receive adequate help when I struggle with biology concepts.					
28. The biology resources (textbooks, online materials) are helpful.					

29. I believe that studying biology will benefit me in my future career.					
30. I am interested in pursuing further studies in biology.					
31. I think that a strong background in biology will be advantageous for my future goals.					
32. I would recommend biology as a subject to other students.					

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1589 **Signature of the Student**

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