

Biology Students Perceptions and Attitudes Toward the Integration of video based Learning in Biology Classrooms in Zaria Local Government Area, Kaduna State

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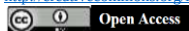
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ABSTRACT

The study focused on the perception and attitude of biology students on the implementation of video-based learning (VBL) in biology classrooms in Zaria Local Government Area (LGA) of Kaduna State. The study used a descriptive survey design. The study population comprises all 18 secondary schools in the study area, with 1,384 SS II Biology students. A sample of 301 students was proportionately selected across schools using Krejcie and Morgan (1970) sample size table. 294 questionnaires were returned and analyzed, and were appropriately completed, resulting in a 97.7% response rate. The Video-Based Learning Perception and Attitude Questionnaire (VBLPAQ) was used to gather data with a 4-point Likert scale. Pearson Product-Moment Correlation was employed to test the relationship between perception and attitude at the 0.05 level of significance, while the mean and standard deviation were employed to answer the descriptive research questions. The preliminary findings suggest that VBL is well perceived ($M = 3.18$, $SD = 0.47$), well attuned ($M = 3.11$, $SD = 0.52$), and positively correlated with attitude ($r = .58$, $p < .001$). The key perceived problems were: Low Electricity Supply ($M = 3.42$, $SD = 0.68$), Limited Display Devices ($M = 3.35$, $SD = 0.71$), and Low Internet Connection ($M = 3.27$, $SD = 0.76$). The results indicate that students are overall positive toward incorporating video in Biology instruction, but they also highlight the need for proper infrastructure, teacher preparation, and pedagogically meaningful use of video to be effective.

Introduction

Science education helps students develop an understanding of phenomena in nature, evidence-based reasoning and problem-solving. Biology is important because it deals with living systems, health, ecology and genetics and processes that are related to many science-related careers. But there are some biological phenomena that are dynamic, microscopic, or hard to demonstrate as they are spatially complex in normal classrooms. This means there is a curriculum requirement for representations to work alongside the textbooks and teacher explanations and practical activities.

Video based learning is the intentional application of recorded or streamed videos, such as demonstrations, animations, narrated explanations, and laboratory directions, to help learning. Its educational value is that it has the ability to represent change, sequence, movement and can give learners the opportunity to pause, replay and review information. Mayer (2021) provides confirmation that meaningful learning can be aided by the use of multimedia, provided that words and images are not presented simultaneously in the wrong order. Research on video-based learning also suggests that design features and how the videos are used in learning have an impact on learning outcomes (Auliya, 2022; Polat, 2023; Weng et al., 2023).

However, technology cannot be expected to enhance learning simply because it is in the school. Evidence about educational technology is inconsistent and decisions made should include the following: evidence, sustainability, equity, and educational relevance (UNESCO 2023). The teacher preparation, pedagogical knowledge, infrastructure, maintenance, and alignment with curriculum goals are identified

as important conditions for reviews of the integration of ICTs in secondary schools (Msambwa et al., 2023, 2024; Claro et al., 2024).

These concerns are also reported in studies conducted in secondary education in Nigeria. Aladeokin and Shehu (2022) reported that there were challenges with the ICT resources for teaching Biology. Despite the positive perceptions on digital competence and positive attitudes among science teachers, Ogegbo (2023, 2024) noted that these factors did not always reflect their use in the classroom due to resource, electricity and support limitations. Likewise, Ekon et al. (2025) found that there was also insufficient ICT resources, training requirements, time constraints, and power outages in the teaching of Biology. These realities warrant being explored through students' perceptions and attitudes towards a specific digital approach, video-based learning, in a specific local context.

Statement of the Problem

While the use of video resources may bring biological processes to the fore and perhaps even make them more interesting, its relevance to a specific classroom will depend on how the learners perceive and react to the video. A video could be technically available but not fully connected with the lesson, be too lengthy, too hard to follow, interrupted power, or not accompanied by teacher questioning and follow-up activities. Availability thus does not necessarily imply educationally acceptable or useful use of VBL. Previous research related to the use of video-based learning in Nigeria has concentrated on the general availability of ICTs, teacher competence, readiness or attitudes instead of the perceptions and attitudes of learners towards using video-based learning specifically. Hence, there is need for evidence from Zaria LGA on the local level. This evidence can be used to ascertain if students perceive VBL as useful and fun to use, if they are positive about its use, if perception is related to attitude, and what are the problems that students see in actual classroom implementation of VBL.

Objectives of the Study

1. Determine Biology students' perceptions of the usefulness and instructional value of video-based learning;
2. Determine Biology students' attitudes toward the integration of video-based learning;
3. Determine the relationship between students' perceptions of video-based learning and their attitudes toward its integration;
4. Identify challenges perceived by students as militating against effective integration of video-based learning.

Research Questions

1. What are Biology students' perceptions of the usefulness and instructional value of video-based learning?
2. What is the attitude of Biology students toward the integration of video-based learning?
3. What relationship exists between students' perceptions of video-based learning and their attitudes toward its integration?
4. What challenges do students perceive as militating against effective integration of video-based learning?

Research Hypothesis

H₀₁: There is no significant relationship between Biology students' perceptions of video-based learning and their attitudes toward its integration in Biology classrooms.

Literature Review

Video based learning may be defined as the educational application of moving images, narration, animation, and demonstrations for the purpose of communicating and/or reinforcing curriculum content. Science education: video may display phenomena that are hard to reproduce such as microscopic phenomena, phenomena in the field, laboratory procedures, and changes in time. The use of video in science-learning research was also found to be able to enhance learning effectiveness as widely used in the learning process (Auliya, 2022). According to the study conducted by Weng et al., (2023), the medium effects on several pre-service teacher outcomes indicated medium effects to be obtained from video-based learning. The study conducted by Polat (2023) revealed that instructor presence and video design are important factors to consider.

The theoretical underpinning of the multimedia learning is applicable in the field of Biology since the students need to manage the information flow both visual and verbal. There are only a limited number

of media that can be used in working memory, so that the more media used, the better the learning is not automatically better, Mayer (2021). Extraneous cognitive load may be caused by poorly designed video. In the field of multimedia learning, recurring issues such as modality, signaling, and presentation format were identified by Mutlu-Bayraktar et al., (2019), whereas Yu et al., (2024) highlighted the challenges in measuring cognitive load in multimedia settings.

In this study, perception refers to the learners' evaluation of usefulness, clarity, relevance, engagement and contribution to understanding. Attitude refers to the positive or negative inclination of learners on the learning of Biology using video. The results of technology acceptance studies show that attitude and intention to use technology is related to perceived usefulness and ease of use of technology (Al-Nuaimi & Al-Emran, 2021; Scherer & Teo, 2019).

The context of the empirical information is also crucial. The study by Ogegbo (2023) revealed that the digital proficiency of science teachers in Nigeria was in the intermediate level, implying that there is a need to develop their competence. The findings indicated that professional development had a positive impact on science teachers' attitudes, beliefs, and intentions to use ICT (Moosa and Ramnarain, 2023). Similarly, Majidadi et al. (2025) found positive attitudes and beliefs of secondary school teachers in Nigeria towards integrating ICT. Inadequate resources, training and power supply are also current challenges as revealed from the Biology specific evidence (Ekon et al., 2025; Inyang & Uchegbue, 2025). The literature thus gives evidence of the relevance of video-based learning and indicates the need for more regional study of the perceptions and attitudes of learners on the topic of VBL in Biology. This study seeks to fill up that void in Zaria LGA.

Methodology

The study adopted descriptive survey design as it aimed to elicit students' perceptions and attitude about the barriers in the learning process without affecting the students' learning context. The population was 1384 SS II Biology students of 18 secondary schools in Zaria LGA Kaduna State. The Krejcie and Morgan (1970) sample size table was used to get a sample of 301 students for the provisional manuscript. The sample was then proportionately allocated to the 18 schools and then students were selected by simple random sampling.

The instrument developed is a Video-Based Learning Perception and Attitude Questionnaire (VBLPAQ) which has been built based on the study objectives and literature. There were four sections. Demographic data was collected using Section A, perceived VBL was measured by seven items using Section B, attitude was measured by six items in Section C and perceived challenge was measured by seven items in Section D, where Agree was rated as 4 and Strongly Disagree as 1. The criterion mean was used with 2.50 being the criterion: means 2.50 or higher were interpreted as agreement/favourable responses; means lower than 2.50 as disagreement/unfavourable responses.

The three experts who were involved in the face and content validation of the instrument were experts from biology, Educational Technology and Measurement and Evaluation, all from Ahmadu Bello University and Federal University of Education, Zaria. The experts recommended changes to the wording for a provisional manuscript that was used for the pilot administration. The Cronbach's alpha values for the pilot study conducted outside the study area with SS II biology students were 0.86 for perception, 0.88 for attitude and 0.82 for challenges and a total Cronbach's alpha value of 0.89. The VBLPAQ was pre-tested with 30 students in secondary school (SS II) Biology of a secondary school outside the study area. The Cronbach's alpha for the perception scale was (0.86), attitude scale (0.88) and challenges scale (0.82) with an overall Cronbach's alpha of (0.89).

The researchers obtained relevant school authorities' consent before administering the questionnaire. The participation was made voluntary and they were assured of confidentiality of their responses. The questionnaires were filled out by biology teachers or research assistants. 294 questionnaires were returned (97.7% usable for analysis). To answer Research Questions 1, 2 and 4, the mean and standard deviation were used; to answer Research Question 3 and test H_{01} (at $\alpha = 0.05$), the Pearson product-moment correlation was used.

Results

The results are presented according to the research questions and hypothesis. A criterion mean of 2.50 was used to interpret the four-point scale.

Table 1

Demographic Characteristics of Respondents			
Variable	Category	Frequency	Percentage
Gender	Male	151	51.4%
	Female	143	48.6%
Age	14–15	62	21.1%
	16–17	174	59.2%
	18+	58	19.7%
Total		294	100.0%

Source: Field Survey, 2026

As shown in Table 1, respondents included 151 (51.4%) males and 143 (48.6%) females, a fairly even gender Ratio. Regarding age, most respondents (174, 59.2%) were aged 16–17 years, followed by 62 (21.1%) aged 14–15 years, while 58 (19.7%) were aged 18 years and above. Overall, the table shows that most respondents were in the normal SS II age range, with approximately equal numbers of male and female students.

Table 2

Students' Perceptions of the Instructional Value of VBL			
Items	Mean	SD	Decision
VBL helps me understand difficult Biology concepts	3.21	0.63	Agree
VBL makes biological processes easier to visualize	3.34	0.58	Agree
I can replay videos when I need clarification	3.29	0.65	Agree
VBL improves my memory of Biology content	3.09	0.71	Agree
VBL makes Biology lessons more engaging	3.25	0.67	Agree
Videos complement practical Biology activities	3.04	0.74	Agree
VBL connects Biology to real-life situations	3.04	0.70	Agree
Cluster Mean	3.18	0.47	Agree

Source: Field Survey, 2026

The cluster mean of 3.18 (SD = 0.47) for the students' perception of the instructional value of VBL is above criterion mean of 2.50 as seen in Table 2, which indicates a favourable perception of the students. The top three items were: VBL makes biological processes easier to visualize (M = 3.34, SD = 0.58); VBL allows students to replay videos for clarification (M = 3.29, SD = 0.65); VBL makes Biology lessons more engaging (M = 3.25, SD = 0.67). Videos to enhance practical Biology activities and linking Biology to real-life situations were the lowest of the rated items (M = 3.04 for both). Overall, the results suggest that VBL was seen as useful by students in terms of improving their understanding, visualization, engagement, and retention of the concepts in Biology.

Table 3

Students' Attitudes Toward VBL			
Item	Mean	SD	Decision
I enjoy Biology lessons when relevant videos are used.	3.18	0.66	Agree
I would like my Biology teacher to use videos more often.	3.24	0.69	Agree
VBL increases my interest in Biology.	3.12	0.73	Agree
I am willing to participate in video-supported lessons.	3.15	0.62	Agree
I would recommend appropriate Biology videos to other students.	3.04	0.76	Agree
I prefer lessons combining explanation with relevant video.	2.93	0.81	Agree
Cluster Mean	3.11	0.52	Agree

Source: Field Survey, 2026

From Table 3, it can be seen that students generally have positive attitudes towards VBL with cluster mean is 3.11 (SD = 0.52) with criterion mean 2.50. The most highly rated were the teachers' desire to use the videos more often (M = 3.24, SD = 0.69), their enjoyment of the Biology lessons when the videos are used (M = 3.18, SD = 0.66), and their willingness to participate in the video supported lessons (M = 3.15, SD = 0.62). The lowest rated item was for the combination of teacher explanation and relevant videos in lessons (M = 2.93, SD = 0.81). Overall, the results indicated that students had a positive attitude toward using VBL in Biology instruction.

Table 4

Relationship Between Perception and Attitude				
Variables	N	R	p	Decision
Perception Attitude	x 294	0.58	<0.001	Sign.

Source: Field Survey, 2026

Students' perception of VBL and their attitude toward its use were moderately positively correlated, $r = 0.58$ ($p < .001$), among 294 respondents (Table 4). Because the p-value is smaller than the 0.05 significance level, the null hypothesis is rejected. This means students with more favorable perceptions of VBL reported more positive attitudes toward its use, showing a direct relationship between the two.

Table 5

Perceived Challenges to VBL			
Challenge	Mean	SD	Decision
Inadequate electricity supply	3.42	0.68	Agreed
Limited display/computer devices	3.35	0.71	Agreed
Poor internet connectivity	3.27	0.76	Agreed
Technical problems	3.19	0.73	Agreed
Insufficient suitable Biology videos	3.07	0.78	Agreed
Limited teacher training	3.01	0.82	Agreed
Time needed to prepare/use videos	2.88	0.84	Agreed
Cluster Mean	3.17	0.59	Agreed

Source: Field Survey, 2026

The mean of 3.17 (SD = 0.59) for all students' responses in Table 5 exceeds the criterion mean of 2.50 and indicates several challenges in using VBL. The most common difficulties were insufficient electricity supply (M = 3.42, SD = 0.68), insufficient display/computer devices (M = 3.35, SD = 0.71), and limited internet connectivity (M = 3.27, SD = 0.76). The lowest-rated challenge was the time required to prepare and use videos (M = 2.88, SD = 0.84). In summary, the results indicate that many challenges remain in effectively integrating VBL into Biology instruction, particularly infrastructure and technical barriers.

Discussion of Findings

For Research Question One, the cluster mean was 3.18 (SD = 0.47), with a criterion mean of 2.50. This shows that respondents' general attitude toward the usefulness of video-based learning as a medium of instruction was positive. The highest item mean was for "VBL makes biological processes easier to visualize" (M = 3.34, SD = 0.58), while the ability to replay videos for clarification was next (M = 3.29, SD = 0.65). This discovery indicates that students are especially interested in the "view" and "recall" aspects of video. These findings align with Auliya (2022), which showed that video can be a useful medium for science learning, and Weng et al. (2023), who found that video-based learning had positive outcomes in science learning. This also aligns with Mayer's (2021) multimedia learning position, which states that words and pictures, when coordinated appropriately, can facilitate meaningful learning. However, the findings are based on students' perceptions and cannot be considered proof of VBL's impact on student achievement in general.

The cluster mean (3.11, SD = 0.52) is higher than the criterion means (2.50), suggesting a generally positive attitude towards integrating VBL. The most positive answer was for the use of more videos by the Biology teacher (M = 3.24, SD = 0.69), and the combining of teacher explanation with video (M = 2.93, SD = 0.81). The findings suggest that pupils do not always see video as a substitute for the teacher, but rather as a tool to use alongside the teacher. This interpretation aligns with Scherer and Teo (2019) and Al-Nuaimi and Al-Emran (2021), whose technology-acceptance evidence (TAE) considers perceived usefulness as a direct contributor to technology-related attitudes and intentions. It also concurs with the findings of Nigerian studies conducted by Moosa & Ramnarain (2023), Majidadi et al. (2025), which generally reported positive orientations towards integrating ICT in education among teachers.

A Pearson correlation was calculated for the research question (H0₁) to produce a r value of .58 with a p value of < 0.001 for 294 respondents. The positive coefficient shows that there exists moderate

positive association between the students' perception of VBL and attitude towards its integration. The p -value is less than the significance level of .05, so the null hypothesis is rejected. Within this sample, then, students who indicated higher ratings of favourability were more likely to indicate favourable attitudes. This finding is in line with the literature on technology acceptance, specifically the notion of perceived usefulness that influences attitudes toward educational technology (Al-Nuaimi & Al-Emran, 2021; Scherer & Teo, 2019). However, as the study was a descriptive survey design, it must be interpreted as an association, and not as a causal effect.

For RQ4, 3.17 (SD = 0.59) with a cluster mean greater than 3 suggests that the overall response was that the factors listed do in fact hinder effective integration of VBL. Lack of electricity (M = 3.42, SD = 0.68), limited display/computer devices (M = 3.35, SD = 0.71), and poor internet connectivity (M = 3.27, SD = 0.76) were the most salient problems. This corresponds with the evidence in Nigeria that has shown that teacher capacity, equipment, electricity, and infrastructure are still major factors that hinder the integration of ICT in schools (Aladeokin & Shehu, 2022; Ogegbo, 2024; Ekon et al., 2025; Inyang & Uchegbue, 2025). The outcome also reinforces the UNESCO (2023) stance, which argues that providing technology is not enough if the infrastructure is lacking, teachers are not supported, and pedagogical planning is not done.

Conclusion

The preliminary results revealed that generally, students of SS II Biology of Zaria LGA have positive attitudes towards the use of video-based learning in the teaching of biology (M = 3.18, SD = 0.47), and positive attitudes towards the integration of video-based learning in the teaching of biology (M = 3.11, SD = 0.52). Another moderate positive and statistically significant correlation was found between perception and attitude ($r = .58$, $p < 0.001$), meaning that the more positive the student's perception of the program, the more positive their attitude. The students also noted the infrastructure and implementation factors, such as insufficient electricity, limited display devices, and weak internet connectivity, as barriers. Overall, the results indicate that VBL can be used as an acceptable supplementary Biology material when used intentionally by the teacher as support for his/her explanation, discussion and practical activities.

Recommendations

1. The key challenges faced in implementing the program identified by the students should be addressed through the improvement of the electricity/backup power, provision of functional display devices, the improved internet access (where possible) and the offering of practical training for teachers in the selection and use of videos in the classroom.

2. Since perception and attitude were found to be significantly and positively correlated, the teachers/schools should provide well-designed and purposeful video-supported lessons that will be accompanied by clear learning objectives and learning tasks to create positive experiences.

3. Students' attitudes were positive towards VBL, so the school Biology department should use appropriate video resources as an aid to teacher's explanation, discussion and practical activities, not as a substitute for class interaction.

Biology teachers should choose short accurate and curriculum related videos, that directly illustrate difficult and dynamic biology concepts, and allow for replay and clarification, based on the favourable perception of VBL.

References

1. Aladeokin, O. J., & Shehu, A. (2022). Availability and usability of ICT as an instructional strategy for improving teaching and learning Biology in Nigerian secondary schools. *Journal of Education and Practice*, 13(16), 85-91. <https://doi.org/10.7176/JEP/13-16-09>.
2. Al-Nuaimi, M. N., & Al-Emran, M. (2021). Learning management systems and technology acceptance models: A systematic review. *Education and Information Technologies*, 26, 5499–5533. <https://doi.org/10.1007/s10639-021-10513-3>.
3. Adam, A. S., & Too, C. (2024). Teachers' attitude towards integration of information and communication technology and its influence on students' performance in Gezawa, Nigeria. *The Educator*, 4(1), 38–50.



4. Børte, K., Lillejord, S., Chan, J., Wasson, B., & Greiff, S. (2023). Prerequisites for teachers' technology use in formative assessment practices: A systematic review. *Educational Research Review*, 41, 100568. <https://doi.org/10.1016/j.edurev.2023.100568>.
5. Claro, M., Castro-Grau, C., Ochoa, J. M., Hinostroza, J. E., & Cabello, P. (2024). Systematic review of quantitative research on digital competences of in-service school teachers. *Computers & Education*, 215, 105030. <https://doi.org/10.1016/j.compedu.2024.105030>.
6. Ekon, E. E., Udoh, N. M., Ntukidem, I. U., & Osu, S. R. (2025). Integration of information and communication technology resources for effective teaching of Biology in selected secondary schools in Ikot Ekpene LGA, Nigeria. *Journal of Science Education and Humanities*, 8(1).
7. Falemu, F. A., & Akinwumi, I. O. (2023). Teachers' readiness for information and communication technology in teaching of Biology in secondary schools in Ekiti State, Nigeria. *International Journal of Library and Information Science Studies*, 9(7), 26–38. <https://doi.org/10.37745/ijliss.15/vol9n72637>.
8. Inyang, M. I., & Uchegbue, H. O. (2025). Evaluation of ICT competence among secondary school Biology teachers: Implications for the 21st-century teacher educators. *Direct Research Journal of Education and Vocational Studies*, 6(2), 88–92.
9. Majidadi, Z. Y., Yushau, B., & Deba, A. A. (2025). Secondary school teachers' attitudes and beliefs on the integration of information and communication technology in teaching. *ATBU Journal of Science, Technology and Education*, 13(1), 201-213.
10. Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press. <https://doi.org/10.1017/9781316941355>.
11. Moosa, S. M., & Ramnarain, U. (2023). The impact of an empowerment evaluation professional development program on physical sciences teachers' attitudes, beliefs and behavioral intentions to integrate ICT into their science lessons. *Frontiers in Education*, 8, 1159373. <https://doi.org/10.3389/feduc.2023.1159373>.
12. Morgado, M., Botelho, J., Machado, V., Mendes, J. J., Adesope, O., & Proença, L. (2024). Video-based approaches in health education: A systematic review and meta-analysis. *Scientific Reports*, 14, 23651. <https://doi.org/10.1038/s41598-024-73671-7>.
13. Msambwa, M. M., Kangwa, D., & Cai, L. (2023). A systematic literature review of ICT integration in secondary education: What works, what does not, and what next? *Discover Education*, 2, 44. <https://doi.org/10.1007/s44217-023-00070-x>.
14. Msambwa, M. M., Kangwa, D., & Cai, L. (2024). Integration of information and communication technology in secondary education for better learning: A systematic literature review. *Social Sciences & Humanities Open*, 10, 101203. <https://doi.org/10.1016/j.ssaho.2024.101203>.
15. Mutlu-Bayraktar, D., Cosgun, V., & Altan, T. (2019). Cognitive load in multimedia learning environments: A systematic review. *Computers & Education*, 141, 103618. <https://doi.org/10.1016/j.compedu.2019.103618>.
16. Auliya, N. (2022). The use of video as a learning media in science learning: A systematic review. *AL-ISHLAH: Jurnal Pendidikan*, 14(4), 6941–6950. <https://doi.org/10.35445/alishlah.v14i4.1565>.
17. Ogegbo, A. A. (2023). Assessing the proficiency level in digital competences of secondary school science teachers. *International Journal of Education and Development using Information and Communication Technology*, 19(2), 40–57.
18. Ogegbo, A. A. (2024). ICT integration into the teaching and learning of science: Experiences and perceptions of secondary school teachers. *African Perspectives of Research in Teaching and Learning Journal*, 8(1), 39-51.
19. Polat, H. (2023). Instructors' presence in instructional videos: A systematic review. *Education and Information Technologies*, 28, 8537–8569. <https://doi.org/10.1007/s10639-022-11532-4>.
20. Rosendahl, P., & Wagner, I. (2024). 360° videos in education: A systematic literature review on application areas and future potentials. *Education and Information Technologies*, 29, 1319–1355. <https://doi.org/10.1007/s10639-022-11549-9>.
21. Scherer, R., & Teo, T. (2019). Unpacking teachers' intentions to integrate technology: A meta-analysis. *Educational Research Review*, 27, 90–109. <https://doi.org/10.1016/j.edurev.2019.03.001>.



22. UNESCO. (2023). Global education monitoring report 2023: Technology in education A tool on whose terms? UNESCO. <https://doi.org/10.54676/UZQV8501>.
23. Weng, X., Ng, O.-L., & Chiu, T. K. F. (2023). Competency development of pre-service teachers during video-based learning: A systematic literature review and meta-analysis. *Computers & Education*, 199, 104790. <https://doi.org/10.1016/j.compedu.2023.104790>.
24. Wohlfart, O., & Wagner, I. (2023). Teachers' role in digitalizing education: An umbrella review. *Educational Technology Research and Development*, 71, 339–365. <https://doi.org/10.1007/s11423-022-10166-0>.
25. Yu, S., Tian, L., Wang, G., & Nie, S. (2024). Which ERP components are effective in measuring cognitive load in multimedia learning? A meta-analysis based on relevant studies. *Frontiers in Psychology*, 15, 1401005. <https://doi.org/10.3389/fpsyg.2024.1401005>.