



Implementing a journal club as a teaching-learning strategy for plant genetics lectures during the COVID-19 pandemic

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Abstract

Plant genetics lectures can be challenging for students to understand due to the abstract nature of the concepts discussed. This generates a lack of interest in students due to the isolation between theoretical and practical concepts which limits critical thinking in students. Virtualization due to the COVID-19 pandemic aggravated this situation with the lack of practical classes due to the closure of laboratories and experimental fields in universities. This work introduces the establishment of a Journal Club (JC) with the collaborative-metacognitive use of the scientific literature teaching approach as a strategy to reinforce theoretical-practical knowledge through the reading of scientific articles in an e-Learning environment. The methodology was applied in two consecutive academic semesters in years 2021 and 2022 in the plant genetics lectures. The students read scientific articles and performed an essay in groups. The results show that more than 80% of the participants agree with the JC implementation and they consider it relevant to their education. The application of the JC allowed the students to integrate knowledge covered in the theoretical lectures. Additionally, students presented improvements in skills within the framework of the seven Cs for critical thinking, teamwork, use of research tools, and in essay writing scores.

Keywords: CMSLTA, crop sciences, research tools, sci-hub, seven Cs, Zotero

Introduction

The World Health Organization declared a pandemic on 11th March 2020, due to the SARS-CoV-2. This brought a new challenge for students and lecturers to implement remote distance learning worldwide (Daniel 2020; Harris et al. 2020). Platforms such as Zoom, Google Meet, and Microsoft Teams became the “new normal”, and the primary venue for teaching and socializing.

A journal club (JC) is one of the well-established and popular graduate and post-graduate education methods with about 200 years of history (Topf et al. 2017). The JC was denominated in this way by Dr. James Paget in 1835. It was so named as the doctors of St. Bartholomew’s Hospital, London, used to sit in a lounge and read the journals. But since their introduction by Sir

William Osler in 1875 as regular meeting for a group of doctors and students to discuss publications where the JC have a long history in the medical sciences (Linzer 1987).

The original purpose of a JC was to help physicians stay up to date with current research and implement the research findings in clinical practice. It promotes group studying and contributes to developing a habit of continuously studying (Wenke et al. 2023). But many aims can be achieved by participants during JC sessions as spreading scientific information and knowledge transfer, keeping up to date with the literature, and developing critical thinking or analytical skills in general. The JC also acts as a motivating tool (Sanwatsarkar et al. 2022) and makes studying more manageable. Despite journal clubs being established as part of the medical education system (Ilic et al. 2020), studies that have investigated the effectiveness of journal clubs as a means of teaching evidence-based to plant science professionals are rare.

The present work was part of a pedagogical training course entitled “Designing my lecture” for professors starting their academic careers at the university. Each professor was encouraged to implement an improvement methodology in one of the lectures of his or her specialty. We describe and analyze the implementation of an e-Learning JC during two academic semesters for plant genetics lectures as collaborative-metacognitive use of science literature teaching approach (CMSLTA). The central hypothesis was that the implementation of JC could improve the seven Cs in students and the capability to relate the topic of the lectures in an environment with a lack of practical knowledge due to COVID restrictions.

Conceptual framing: e-Learning, Journal Club, CMSLTA, Seven Cs and pedagogy

e-Learning: online or distance learning

e-learning is a term that refers to online or distance learning, which uses digital technologies to deliver education and training over the Internet (Clark and Mayer 2016; Mahdizadeh et al. 2008). Learning materials are delivered through an online learning platform and may include videos, readings, quizzes, discussion forums, and other interactive activities (Ganzert et al. 2017). Students can access learning materials from anywhere and at any time, giving them greater flexibility in their learning (Mayer 2003).

During the COVID-19 pandemic, many universities around the world adopted e-learning to continue online teaching and learning (Daniel 2020). The pandemic forced many educational

institutions to temporarily close their campuses and look for alternatives to continue offering education to students (Mahdi 2023). e-learning became a popular option, as it allowed students to continue their education from home and remain safe during the pandemic. Many universities used online tools and platforms to offer live, recorded lectures, assignments, and assessments to students.

Journal Club

A journal club is a group meeting where recent scientific articles are discussed. These meetings are common in academic and medical settings, but can also be held in other contexts, such as in a company or study group (Aweid et al. 2022; Golden 2023; Sanwatsarkar et al. 2022). Journal clubs have been widely used by clinicians for over a century to enhance critical appraisal skills (Ianno et al. 2020; Ilic et al. 2020; Linzer 1987).

The main objective of a journal club is to promote critical discussion and exchange of ideas about recent research in a given field. Participants read and analyze selected articles before the meeting, and then discuss their findings, methods, and conclusions. This helps keep participants up to date with the latest research and allows them to learn from others (Wenke et al. 2023). A journal club can also be an opportunity to improve critical and communication skills, as participants must explain and justify their views in a respectful and constructive environment.

In a university environment, a journal club can be an excellent way to encourage critical discussion and the exchange of ideas between students and professors. Students can have the opportunity to learn from professors and peers about the latest research in their field, and professors can take the opportunity to guide students in critically analyzing the literature (Golden 2023).

Collaborative-metacognitive use of science literature teaching approach (CMSLTA)

The Collaborative-metacognitive use of science literature teaching approach (CMSLTA) is a pedagogical strategy that focuses on the use of collaborative and metacognitive scientific literature to enhance comprehension and critical thinking in science students (Daloos and Paderna 2023). The goal of the CMSLTA approach is to help students develop skills in reading, comprehending, analyzing, and evaluating scientific texts, as well as working in teams to discuss and solve complex problems in science (Hogan et al. 2015; Sandi-Urena et al. 2011). The CMSLTA strategy is based

on the idea that active and collaborative learning, as well as metacognitive reflection on the learning process itself, can enhance understanding of science and promote advanced cognitive skills.

The journal club could be considered CMSLTA. It refers to a teaching approach that engages students in the discussion and critical analysis of scientific literature, with a focus on the development of metacognitive skills, such as reflection and self-regulation.

In the context of the present implementation of JC, students work together to read and analyze scientific articles and discuss their findings, methods, and conclusions. This allows them to develop metacognitive skills by reflecting on their learning process and considering the perspective of others. In addition, working collaboratively in a journal club allows students to learn from their peers and teachers, and improve their communication and presentation skills. It also allows them to learn to work in teams and to develop leadership and problem-solving skills.

Seven Cs

The concept of the seven Cs refers to a framework of twenty-first-century skills and is composed of seven key elements: communication, collaboration, creativity, critical thinking, cross-cultural understanding, computerized/information and communication technologies, and career/lifelong learning (Daloos and Paderna 2023). These elements are important for any type of communication, whether written or oral, and are especially useful in professional and academic environments. By following the principles of the seven Cs, the quality of communication can be improved and the comprehension and effectiveness of the messages transmitted can be increased.

The implementation of a journal club could reinforce the following concepts:

1. Communication: The JC allows students to develop their communication skills by presenting their findings and discussing their ideas with their peers and professors.
2. Collaboration: By working together to analyze and discuss scientific literature, students can develop collaborative skills and learn to work as a team.
3. Critical thinking: By analyzing and discussing scientific literature, students can develop their ability to think outside the box and find creative solutions to scientific problems.
4. Criticism: By evaluating and discussing scientific literature, students can develop their critical thinking skills and evaluation of evidence.

5. Cross-cultural understanding: By learning about research in a global context, students can develop a deeper and more respectful understanding of different cultures and perspectives.
6. Computerized/information and communication technologies: By using technology to explore, read and discuss scientific literature, students can develop their digital skills.
7. Career/lifelong learning: JC is an active learning methodology that promotes keeping up-to-date with the literature and promotes self-learning allowing long-term learning.

Pedagogical Skills in Science Education

University professors usually have specialized academic training in their field of study, however, they may lack the pedagogical skills to teach science. Many university professors have obtained additional training in pedagogy or have experience teaching science (Ganzert et al. 2017). Some university professors may not have formal pedagogical training and may have difficulty applying effective teaching techniques. In these cases, the university institution can provide training and support to help university professors develop pedagogical skills (Zohar and Schwartz 2011). The pandemic highlighted an ongoing need for educational research on pedagogy (Singer et al. 2013), and how instructors may be able to most effectively shift teaching from face-to-face to remote teaching modalities (Barton 2020).

The journal club could be classified as an active and participatory pedagogical tool. In this type of teaching, students are responsible for their learning and actively participate in the discussion and analysis of scientific literature (Shah et al. 2022). The present implementation includes essay writing to promote conceptual learning, critical thinking, and communication skill (Dowd et al. 2018). In this context, JC could be considered a project-based pedagogical tool, as students are tasked with reading and analyzing scientific articles and then presenting and discussing their findings (i.e. essay). This project-based approach encourages problem-solving, collaboration, and creativity, and allows students to apply their knowledge to real situations.

Methodology

Scope and Delimitations

The journal club (JC) was implemented in the plant genetics lecture. A total of 90 students between the sixth and seventh cycle of the agronomy course participated. The implementation took place

during two academic semesters in the years 2021 and 2022. Each academic semester has a period of 16 weeks. The project was endorsed and approved by the university. The students were informed of the project and the surveys were conducted voluntarily.

Teaching Approach

The JC methodology was divided into four stages. The training stage was given only once per academic semester to all students. The following three steps (i.e. reading, writing, and discussion) were repeated for each article with a duration of 60 minutes per session (Figure 1). Although the oral language was Spanish, all the papers were read in English (Table 1). All lectures were conducted virtually through the Zoom platform.

Training (Research tools): Students learn diverse tools that will enable the appropriate use of software and applications for reading articles and writing essays. Among these tools was Zotero in the desktop version as the web connector, Google Docs, Hypothesis, and web translators (i.e., Google Translate, DeepL, and DocTranslator). The training stage was in the first week of each semester and took 120 minutes.

Week 1 (Reading articles): Students were assigned into random groups of three to four. The groups and the randomization were made automatically in the Moodle system. At the beginning of the lecture, the journal article was introduced and the students had 30 minutes to read it and extract all the essential information. At the end of the reading time, the main points in the article are discussed (i.e. topic, research question, hypothesis, main results)

Week 2 (Essay writing): In the first 40 minutes the students in groups began to organize the writing of their essays. In the remaining 20 minutes, guidance on how to improve the essay writing or provided feedback on the essays from the previous JC was conducted.

Week 3 (Reading discussion): In the first 30 minutes, students were randomly grouped with members of other groups to discuss their ideas and views on reading. At the end of that period, all students were returned to the main room for the general discussion guided by the professor. In case there were no initial opinions, the professor asked questions and probed their reading to encourage further discussion by presenting different ideas and opinions. In some sessions, slides were used to present case studies or experiences about the reading topic to motivate the discussion. At the end of the session, the students have to submit their essays as the final product of JC.

Instrument

Survey design: A survey was designed to determine the level of satisfaction with the JC implementation. In addition, objective questions were included to evaluate the tools that participants learned and used during the academic semester. The survey was voluntary and anonymous to allow students to express their opinion without any restrictions.

Objective rubric: Writing an essay was the final product of each journal club series (i.e., every three weeks). Grading was based on the use of an objective rubric. The grading system was from 0 to 20, where 20 is the highest grade. The names of the participants were removed from the grading book to maintain the privacy of the students.

Data Collection and Analysis

Data analysis was performed in the statistical software R version 4.2.2 (R Core Team, 2020). The scores were analyzed in a linear model taking into account the interaction of the factors: the journal club sessions, the section, and the semester of methodology implementation. The results were subjected to an analysis of variance to analyze the interaction between the factors. The estimated marginal means and the pair-wise comparisons test were performed with *emmeans* (Lenth et al. 2023) and *multcomp* (Hothorn et al. 2023) R package respectively. The graphs were made with the *inti* package. Qualitative data analysis and graphs were analyzed by the frequency of occurrence of terms with the *wordcloud* package (Fellows 2018).

The reproducible analysis was performed under *Quarto* (Allaire et al. 2023) an open-source scientific and technical publishing system (Supplementary File 1).

Results

Student perception

An objective survey was designed to evaluate the students' perception of the journal club under synchronous e-Learning due COVID-19 pandemic. The survey was applied at the end of the semester at plant genetic lectures during two academic semesters in the years 2021 and 2022.

About 84.4% of the students agreed with the JC implementation and 83.3% considered it relevant to their education. Regarding the article read, 74.4% liked the articles chosen, whereas 84.4% indicated that the number of articles was adequate for the duration of the course. Additionally, 60% considered not reducing the number of articles, and 45% suggested increasing the number of articles to read. According to 87.8% of students, the timelapse for each JC was adequate. At least 14% of the student rated the chosen articles as difficult to understand, whereas 72.2% of students found their understanding medium to difficult (Figure 2).

Research tools and training

The frequency with which each tool was used by the students was evaluated to determine the relevance of the training in the use of research tools during JC implementation

The frequency of the tools was divided into five groups represented by the colors: forest-green, blue, orange, purple, and gray (Figure 3). The first group included Google Docs, Google Scholar, and Zotero with 11.9%, 10.7%, and 10.3%, respectively; while Sci-Hub and iLovePDF were in the second group with 9.3% and 9.1% respectively. The third group only included onlinedoctranslator with 5.6%. DeepL, Scimago Journal & Country Rank, and Foxit Reader were in the fourth group with 4.2%, 3.8%, and 3%, respectively. Tools such as Hypothesis, Articulate, and Grammarly represented less than 3% each.

Progress in essay grades

Essay by groups was the final product of each journal club. Essay grades after each journal club were compared among the five sections during two academic semesters in the plant genetics lecture.

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Sections A and D presented an increase in the grades in time in both semesters. In the 2021-2 semester group A started with a score of 17.5 and at the end got a score of 18.4, whereas group D had 17 and 17.2, respectively, for the same evaluations. In the 2022-1 semester group A started with 14.8 and ended with a score of 17.9, whereas group D had 16.5 and 18.6 gradings, respectively, for the same evaluations. For both sections, A and D showed a continued improvement in their grading over time during the two academic semesters (Figure 4). Section D reduced their grading in 2021-1 for JC two and four and JC three in 2022-1 (Figure 4). This reduction was associated with the type of articles (i.e., research articles, Table 1).

Section B in the 2022-1 semester did not show an improvement in the grading during the period of the JC. The initial grading for this group was 15.5 and ended with a grading of 15 (Figure 4).

Discussion

With the advent of the COVID-19 pandemic in 2020, there was a huge change in the development of lectures in the university worldwide (Barton 2020; Daniel 2020; Ozkara et al. 2022). Synchronous and asynchronous e-Learning became the main environment in which students interacted. Active learning classroom strategies need to be generated to engage the interest and motivation of students (Garcia-Vedrenne et al. 2020). We analyzed the implementation of a synchronous e-Learning journal club at plant genetics lectures. The results show that there is a positive perception of students towards the implementation of a journal club based on the application of a collaborative-metacognitive use of science literature teaching approach (CMSLTA).

For a long time, JC was used for teaching and knowledge sharing in medicine (Aweid et al. 2022; Ozkara et al. 2022), and in post-graduate education (Taverna et al. 2022). The JC approach was found to be educationally valuable, thus aiding in developing critique skills, promoting research awareness, and professional empowerment, and generating a positive research culture and evidence-based practice (Xiong et al. 2018). The JC implementation received excellent feedback from participants. Our results reveal that 83% of the participants who participated in the implementation of the JC in the plant genetics lecture found it productive, and relevant to their formal education and they agreed with its implementation.

Meetings lasted ca.1 hour per week. An improvement in student interaction was achieved since the activities were in groups and open discussions with all the participants. Additionally, the students showed an improvement in their academic reading ability because the JC implies active learning (Ragland et al. 2023). Nevertheless, there was a reduction in grades when the students were exposed to reading and discussing research articles. However, there was an increase in the grading in four out of the five groups in the two evaluated academic semesters. Similar results were found by other authors during the JC sessions where the participants showed increased knowledge and critical thinking (Golden 2023; Ilic et al. 2020; Taverna et al. 2022).

In plant sciences lectures, field practices are an important component in the education of the students (Fleischner et al. 2017). Since the closure of the university campus due to COVID-19 and the quick transition to online courses, students were isolated from their respective universities with a negative impact on their education (McKim et al. 2021; Sahu 2020). Therefore, the JC is

presented as a relevant alternative to an e-Learning approach to promoting the discussion and participation of students to strengthen the knowledge acquired in the theoretical lectures. In addition, the curricular structure of the lectures (i.e. syllabus) describes the themes presented in an isolated manner, which makes it difficult to understand the knowledge as a whole. By utilizing the CMSLTA approach within the JC, students are empowered to explore and analyze the latest scholarly literature while actively discussing its relevance and practical applications.

The implementation of a JC at plant genetics helps strengthen skills such as critical thinking, teamwork, independent learning, tolerance to different opinions, and digital skills included in the seven Cs framework. An advantage of implementing a journal club with essay writing is the reduction of cheating and plagiarism (Reynolds et al. 2020). The use of articles allows for the diversification of readings in each semester. In most cases, the students benefit from the state of the art in the studied area and associate the theoretical knowledge that they are learning. However, our findings indicate that numerous students turn to platforms such as Sci-Hub due to limited access to up-to-date study materials, as the universities are not subscribed to relevant journals (Wan 2023). It is essential to recognize that employing such resources involves the infringement of intellectual property rights and copyright laws (Hoy 2017). Consequently, it becomes imperative to pursue legitimate and ethical alternatives that enable university students to access academic information while upholding the principles of copyright laws (Pastor-Ramon et al. 2023).

The limitation of the present work was the design of the instrument for qualitative data collection. The instrument was based on survey research methods. The authors of this manuscript recognize the survey would have yielded more in-depth data. However, the choice was made to gather data as a preliminary, and timely, analysis of the JC implementation during the COVID-19 pandemic as an active learning strategy. Despite the limitations, we believe this study yields valuable insights.

The implementation of JC even after the post-COVID pandemic could be productive as some universities continue with a hybrid model for online teaching-learning because they provide a flexible and feasible platform for evidence-based e-Learning (Ozkara et al. 2022). Whilst from Educators' perspective support the idea that we should teach science as a means of acquiring knowledge, emphasizing the procedures of scientific inquiry rather than the mere memorization of

facts (Moore 1984). The JC is an effective active pedagogical tool to promote project-based learning, which allows students to learn autonomously and apply their knowledge to real situations. The implementation of a JC promotes the development of skills contained in the Seven Cs and the critical analysis of scientific literature, with a focus on the development of metacognitive and collaborative skills.

Conclusion

The implementation of a journal club in plant science lectures has presented an alternative that promoted the engagement of students with their learning and created a venue for academic discussions under the lack of field practice. The students perceive the JC as relevant to their formal education and they agree with its implementation. Additionally, the JC allows students to complement their theoretical knowledge and develop soft skills that are essential for success in the modern world and their lifelong learning. The dynamic learning experience of JC remains applicable and relevant beyond the confines of the COVID-19 pandemic, whether in an e-Learning setting or through traditional face-to-face lectures.

Data availability

The data and the reproducible analysis are available in Supplementary File 1.

Disclosure statement

No potential conflict of interest was reported by the authors

Ethics statement

The project was endorsed and approved by the university. The participants were informed of the study purpose, and their participation was voluntary and anonymous.

References

Allaire, J. J., Teague, C., Scheidegger, C., Xie, Y., & Dervieux, C. (2023). Quarto: open-source scientific and technical publishing system built on Pandoc. <https://quarto.org/>

Aweid, B., Haider, Z., Wehbe, M., & Hunter, A. (2022). Educational benefits of the online journal club: A systematic review. *Medical Teacher*, 44(1), 57–62. <https://doi.org/10.1080/0142159X.2021.1963424>

Barton, D. C. (2020). Impacts of the COVID-19 pandemic on field instruction and remote teaching alternatives: Results from a survey of instructors. *Ecology and Evolution*, 10(22), 12499–12507. <https://doi.org/10.1002/ece3.6628>

Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. John Wiley & sons. <https://onlinelibrary.wiley.com/doi/book/10.1002/9781119239086>

Daloos, Ma. L. A. S., & Paderna, E. E. S. (2023). Enhancing Students’ Concept Understanding Through Collaborative-Metacognitive Use of Science Literature. *Research in Science Education*, 53(1), 81–97. <https://doi.org/10.1007/s11165-022-10049-7>

Daniel, S. J. (2020). Education and the COVID-19 pandemic. *Prospects*, 49(1), 91–96. <https://doi.org/10.1007/s11125-020-09464-3>

Dowd, J. E., Thompson, R. J., Schiff, L. A., & Reynolds, J. A. (2018). Understanding the Complex Relationship between Critical Thinking and Science Reasoning among Undergraduate Thesis Writers. *CBE—Life Sciences Education*, 17(1). <https://doi.org/10.1187/cbe.17-03-0052>

Fellows, I. (2018). wordcloud: Word Clouds. <https://CRAN.R-project.org/package=wordcloud>

Fleischner, T. L., Espinoza, R. E., Gerrish, G. A., Greene, H. W., Kimmerer, R. W., Lacey, E. A., et al. (2017). Teaching Biology in the Field: Importance, Challenges, and Solutions. *BioScience*, 67(6), 558–567. <https://doi.org/10.1093/biosci/bix036>

Ganzert, M., Huber, S., Kaya, M., Sepin, S., & Melzer, P. (2017). Adoption, Usage, and Pedagogy of E-Learning Tools in University Teaching. *UK Academy for Information Systems Conference Proceedings 2017*. <https://aisel.aisnet.org/ukais2017/81>

Garcia-Vedrenne, A. E., Orland, C., Ballare, K. M., Shapiro, B., & Wayne, R. K. (2020). Ten strategies for a successful transition to remote learning: Lessons learned with a flipped course. *Ecology and Evolution*, 10(22), 12620–12634. <https://doi.org/10.1002/ece3.6760>

Golden, A. (2023). Teaching graduate research skills in genomics via an integrated ‘flipped’ journal club program. *Biochemistry and Molecular Biology Education*, 51(1), 57–64. <https://doi.org/10.1002/bmb.21694>

Harris, B. N., McCarthy, P. C., Wright, A. M., Schutz, H., Boersma, K. S., Shepherd, S. L., et al. (2020). From panic to pedagogy: Using online active learning to promote inclusive instruction in ecology and evolutionary biology courses and beyond. *Ecology and Evolution*, 10(22), 12581–12612. <https://doi.org/10.1002/ece3.6915>

Hogan, M. J., Dwyer, C. P., Harney, O. M., Noone, C., & Conway, R. J. (2015). Metacognitive Skill Development and Applied Systems Science: A Framework of Metacognitive Skills, Self-regulatory Functions and Real-World Applications. In A. Peña-Ayala (Ed.), *Metacognition: Fundamentals, Applications, and Trends: A Profile of the Current State-Of-The-Art* (pp. 75–106). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-11062-2_4

Hothorn, T., Bretz, F., Westfall, P., Heiberger, R. M., Schuetzenmeister, A., & Scheibe, S. (2023). multcomp: Simultaneous Inference in General Parametric Models. <https://cran.r-project.org/package=multcomp>

Hoy, M. B. (2017). Sci-Hub: What Librarians Should Know and Do about Article Piracy. *Medical Reference Services Quarterly*, 36(1), 73–78. <https://doi.org/10.1080/02763869.2017.1259918>

Ianno, D. J., Mirowska-Allen, K., Kunz, S. A., & O’Brien, R. (2020). Journal clubs in Australian medical schools: prevalence, application, and educators’ opinions. *Journal of Educational Evaluation for Health Professions*, 17. <https://doi.org/10.3352/jeehp.2020.17.9>

Ilic, D., de Voogt, A., & Oldroyd, J. (2020). The use of journal clubs to teach evidence-based medicine to health professionals: A systematic review and meta-analysis. *Journal of Evidence-Based Medicine*, 13(1), 42–56. <https://doi.org/10.1111/jebm.12370>

Lenth, R. V., Buerkner, P., Giné-Vázquez, I., Herve, M., Jung, M., Love, J., et al. (2023). emmeans: Estimated Marginal Means, aka Least-Squares Means. <https://cran.r-project.org/package=emmeans>

Linzer, M. (1987). The journal club and medical education: over one hundred years of unrecorded history. *Postgraduate Medical Journal*, 63(740), 475–478. <https://doi.org/10.1136/pgmj.63.740.475>

Mahdi, Z. A. (2023). Enhancement of Technology in Pedagogy and Practice in Higher Education during Covid-19. *SHS Web of Conferences*, 156, 05001. <https://doi.org/10.1051/shsconf/202315605001>

Mahdizadeh, H., Biemans, H., & Mulder, M. (2008). Determining factors of the use of e-learning environments by university teachers. *Computers & Education*, 51(1), 142–154. <https://doi.org/10.1016/j.compedu.2007.04.004>

Mayer, R. E. (2003). Elements of a Science of E-Learning. *Journal of Educational Computing Research*, 29(3), 297–313. <https://doi.org/10.2190/YJLG-09F9-XKAX-753D>

McKim, A. J., Sorensen, T. J., & Burrows, M. (2021). The COVID-19 pandemic and agricultural education: An exploration of challenges faced by teachers. *Natural Sciences Education*, 50(1). <https://doi.org/10.1002/nse2.20060>

Moore, J. A. (1984). Science as a Way of Knowing—Evolutionary Biology. *American Zoologist*, 24(2), 467–534. <https://doi.org/10.1093/icb/24.2.467>

Ozkara, B. B., Karabacak, M., & Alpaydin, D. D. (2022). Student-Run Online Journal Club Initiative During a Time of Crisis: Survey Study. *JMIR Medical Education*, 8(1), e33612. <https://doi.org/10.2196/33612>

Pastor-Ramon, E., Aguirre, O., García-Puente, M., María Morán, J., & Herrera-Peco, I. (2023). Sci-Hub use among Spanish researchers: Enemy or a learning opportunity for libraries? *Journal of Information Science*, 01655515221142432. <https://doi.org/10.1177/01655515221142432>

R Core Team. (2020). *R: A language and environment for statistical computing* (manual). Vienna, Austria. <https://www.R-project.org/>

Ragland, E. C., Radcliffe, S., & Karcher, E. L. (2023). A review of the application of active learning pedagogies in undergraduate animal science curricula. *Journal of Animal Science*, 101. <https://doi.org/10.1093/jas/skac352>

Reynolds, J. A., Cai, V., Choi, J., Faller, S., Hu, M., Kozhumam, A., et al. (2020). Teaching during a pandemic: Using high-impact writing assignments to balance rigor, engagement, flexibility, and workload. *Ecology and Evolution*, 10(22), 12573–12580. <https://doi.org/10.1002/ece3.6776>

Sahu, P. (2020). Closure of Universities Due to Coronavirus Disease 2019 (COVID-19): Impact on Education and Mental Health of Students and Academic Staff. *Cureus*, 12(4). <https://doi.org/10.7759/cureus.7541>

Sandi-Urena, S., Cooper, M. M., & Stevens, R. H. (2011). Enhancement of Metacognition Use and Awareness by Means of a Collaborative Intervention. *International Journal of Science Education*, 33(3), 323–340. <https://doi.org/10.1080/09500690903452922>

Sanwatsarkar, S., Palta, S., Parida, S., Kamat, C., & H, B. S. (2022). How to do a journal club, a seminar and a webinar? *Indian Journal of Anaesthesia*, 66(01), 27–33. https://doi.org/10.4103/ija.ija_1108_21

Shah, V., Murthy, S., Warriem, J., Sahasrabudhe, S., Banerjee, G., & Iyer, S. (2022). Learner-centric MOOC model: a pedagogical design model towards active learner participation and higher completion rates. *Educational technology research and development*, 70(1), 263–288. <https://doi.org/10.1007/s11423-022-10081-4>

Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (2013). Biology Education Research: Lessons and Future Directions. *CBE—Life Sciences Education*, 12(2), 129–132. <https://doi.org/10.1187/cbe.13-03-0058>

Taverna, M., Bucher, J. N., Weniger, M., Gropp, R., Lee, S. M. L., Mayer, B., et al. (2022). Perception of journal club seminars by medical doctoral students: results from five years of evaluation. *GMS Journal for Medical Education*, 39(1). <https://doi.org/10.3205/zma001525>

Topf, J. M., Sparks, M. A., Phelan, P. J., Shah, N., Lerma, E. V., Graham-Brown, M. P. M., et al. (2017). The Evolution of the Journal Club: From Osler to Twitter. *American Journal of Kidney Diseases*, 69(6), 827–836. <https://doi.org/10.1053/j.ajkd.2016.12.012>

Wan, S. (2023). Which Nationals Use Sci-Hub Mostly? *The Serials Librarian*, 0(0), 1–5. <https://doi.org/10.1080/0361526X.2023.2193613>

Wenke, R., Stehlik, P., Gerrard, J., Mickan, S., & Henry, D. (2023). Using a journal club to navigate a maze of COVID-19 papers in a front-line hospital service. *BMJ Evidence-Based Medicine*. <https://doi.org/10.1136/bmjebm-2022-112130>

Xiong, L., Giese, A.-K., Pasi, M., Charidimou, A., van Veluw, S., & Viswanathan, A. (2018). How to Organize a Journal Club for Fellows and Residents. *Stroke*, 49(9), 283–285. <https://doi.org/10.1161/STROKEAHA.118.021728>

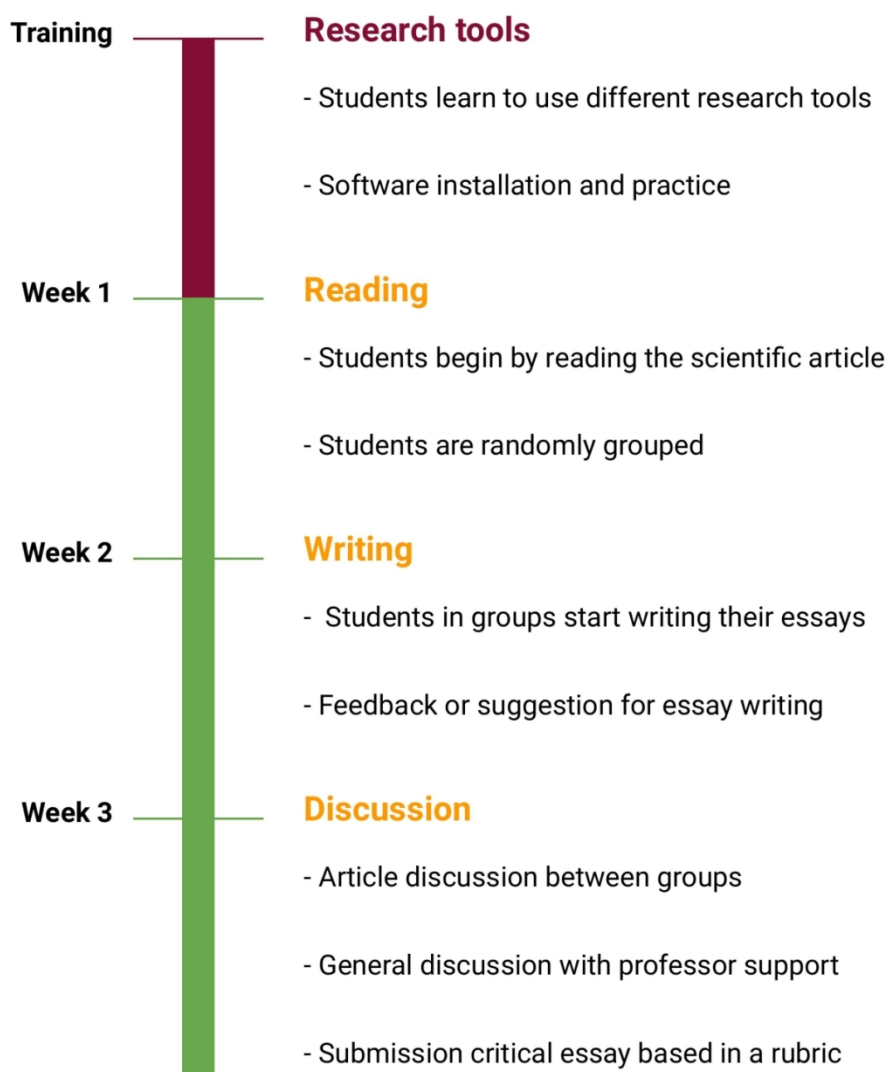
Zohar, A., & Schwartz, N. (2011). Assessing Teachers’ Pedagogical Knowledge in the Context of Teaching Higher-order Thinking. *International Journal of Science Education*, 27(13), 1595–1620. <https://doi.org/10.1080/09500690500186592>

Table 1: Reading list for the journal club implemented during the academic semesters in 2021 and 2022 in the Plant Genetics lectures amidst the COVID-19 pandemic.

JC	Semester	Title	Year	Journal	Type
1	2021	Breeding crops to feed 10 billion	2019	nature	review
				biotechnology	article
2	2021	Imaged-based phenotyping accelerated QTL mapping and $qtl \times$ environment interaction analysis of testa colour in peanut (<i>Arachis hypogaea</i>)	2021	plant breeding	research article
3	2021	Genetic patterns offer clues to evolution of homosexuality	2021	nature	news
4	2021	Heritability in Morphological Robot Evolution	2021	arxiv	research article
1	2022	Genome-edited crops for improved food security of smallholder farmers	2022	nature genetics	review article
2	2022	Crucial factors for the feasibility of commercial hybrid breeding in food crops	2022	nature plants	review article
3	2022	Semiautomated Feature Extraction from RGB Images for Sorghum Panicle Architecture GWAS	2019	plant physiology	research article
4	2022	A chromosome predisposed for sex	2022	nature	news

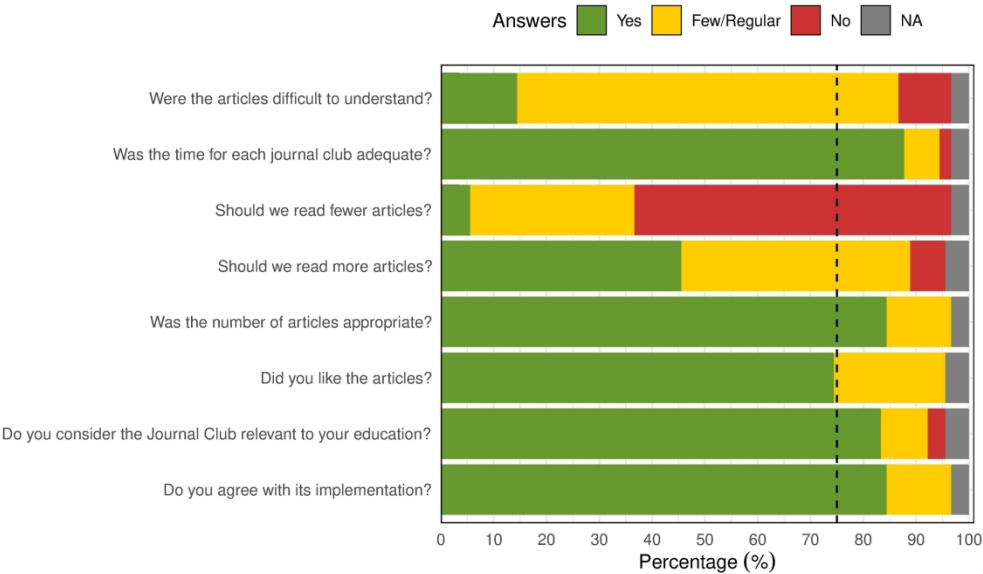
Table 2: Questions of the survey to evaluate the level of satisfaction of the journal club in the plant genetics lectures during the period 2021 and 2022.

Number	Question
1	Were the articles difficult to understand?
2	Was the time for each journal club adequate?
3	Should we read fewer articles?
4	Should we read more articles?
5	Was the number of articles appropriate?
7	Did you like the articles?
8	Do you consider the journal club relevant to your education?
9	Do you agree with its implementation?



Teaching approach of the journal club implementation in plant genetics lectures during two academic semesters in years 2021 and 2022. Training, the students learned different tools to read, write, and discuss scientific documents. In week 1, the article was shared and the students began reading it. The students in groups started writing their essays in week 2, while in week 3, they discussed in random groups the assigned paper. Week 1 to 3 was repeated 4 times per academic semester.

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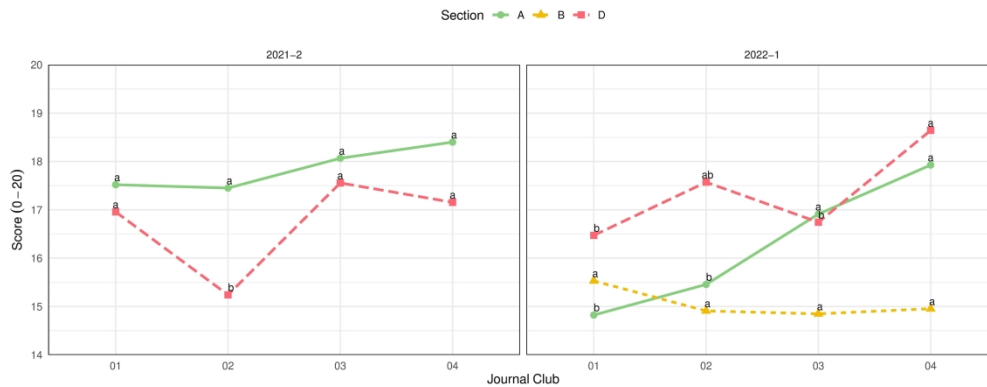
Student perception on the application of the journal club teaching approach during two academic semesters in years 2021 and 2022 in the plant genetics lectures. The dashed line represents 75% of the participants and NA represents the questions not answered by the students. Results were based on a survey conducted on 90 students.

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Research tools learned and used by students during the implementation of the journal club in the plant genetics lectures during the period 2021 and 2022. Results based on the frequency with which each tool was mentioned in 90 students surveyed.

203x203mm (300 x 300 DPI)



Essays grading during the implementation of journal club during two academic semesters in years 2021 and 2022 for synchronous e-Learning at plant genetics lectures in five different sections. The grading system was from 0 to 20, where 20 is the highest grade. Results were based on the grading book from the five sections with a total of 90 students.

299x119mm (300 x 300 DPI)