

Bonsai Fridays: Cultivating Long-Term Skills Beyond Challenge-Based Learning Cycles

Ronnie Paskin, Pontifical Catholic University of Rio de Janeiro, Brazil
Ricardo Venieris, Pontifical Catholic University of Rio de Janeiro, Brazil
Guilherme Toledo, Pontifical Catholic University of Rio de Janeiro, Brazil
Debora Cardador, Pontifical Catholic University of Rio de Janeiro, Brazil
Flora Nolasco, Pontifical Catholic University of Rio de Janeiro, Brazil
Rafael Nasser, Pontifical Catholic University of Rio de Janeiro, Brazil

The European Conference on Education 2025
Official Conference Proceedings

Abstract

This paper addresses a recurring issue when applying Challenge-Based Learning (CBL) in the development of digital products: the limited lifespan of solutions developed during the “Act” phase precludes students from developing a broader range of competencies that require longer sustained effort and iteration. To address this, we propose and evaluate “Bonsai Fridays,” a novel pedagogical approach in which students revisit and iterate on past CBL solutions. This study investigates whether sustained engagement with the output of previous challenges can extend the impact of the “Act” phase, enhance student ownership of their work, and foster long-term skill development. Drawing on established CBL principles (emphasizing real-world problem-solving and action-oriented learning), this study examines how “Bonsai Fridays” promotes the development of student competencies in areas such as marketing, coding, design, and process, that would demand long CBL cycles. It further explores whether this approach increases students' accountability for their solutions by incorporating iterative improvements such as debugging, optimization, and marketing strategies, within a context of active learning and spaced practice for skill retention. The methodology used in this study includes a literature review of CBL in higher education and an evaluation of “Bonsai Fridays” through case studies involving 8 student-developed applications revisited by 40 students over 10 weeks. Findings highlight the benefits and challenges of this extended CBL approach, including its potential to deepen learning outcomes and sustain student engagement. The paper concludes with recommendations towards maximizing educational impact and preparing students for real-world challenges.

Keywords: challenge-based learning, active learning, higher learning, spaced practice

iafor

The International Academic Forum
www.iafor.org

The goal of the “Act” phase is to develop and implement solutions in authentic settings, acting on the knowledge and skills gained, and gathering feedback. This phase includes the development, implementation, and evaluation of the solution, which is often a digital product such as a smartphone or tablet application (although it could take many forms, since CBL is intentionally flexible). Learners are encouraged to be creative in designing their solutions; prototype testing and development may lead them to cycle back to the investigation phase until a solution is ready (Nichols et al., 2016). Typically, once the “Act” phase is completed and the CBL cycle concludes, solutions are not actively maintained or even further developed, as learners shift their focus to exploring new big ideas, challenges, prototypes, and solutions.

This study investigates the possibility of maintaining solutions beyond the “Act” phase. This investigation allows us to examine whether this approach, or a similar one, may accomplish educational goals such as (1) providing learners with opportunities to develop competencies that require longer sustained effort and iterations, beyond the typical challenge durations of a few days to a few months, without having to extend a full CBL cycle over the course of several months; (2) deepening student ownership and accountability for their solution beyond the end of the CBL cycle; (3) extending the impact of CBL beyond isolated cycles; and (4) expanding the educational value of CBL pedagogies. Since our learners are all undergraduate students, we focused this study on higher education.

Literature Review

CBL is a multidisciplinary approach and is analyzed from different perspectives in published literature. Snyder (2019) observes that a semi-systematic review approach is beneficial when researching diverse disciplines and can be useful for detecting themes, theoretical perspectives, or common issues.

Table 1

Databases, Advanced Search Queries and Number of Results

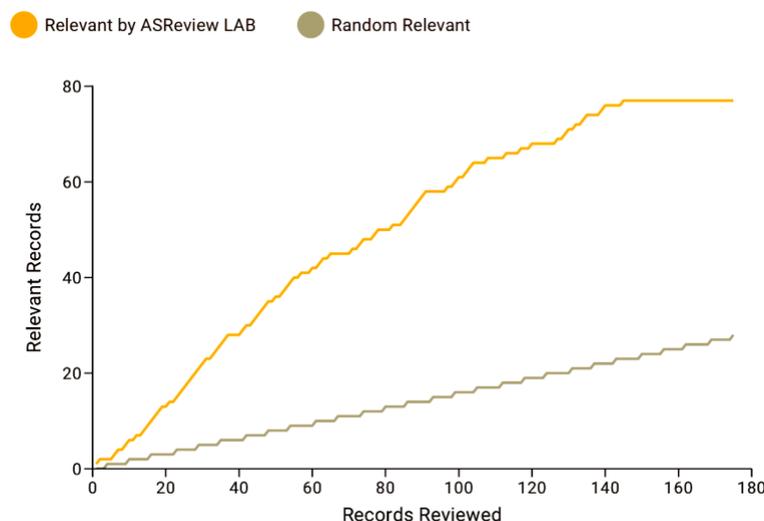
Database	Advanced Search Query	Results
ACM Digital Library	[Full Text: “challenge based learning”] AND [[Full Text: “higher learning”] OR [Full Text: “university”]] AND [E-Publication Date: (01/01/2015 TO 12/31/2025)]	269 (39.2%)
IEEE Digital Library	((“Full Text & Metadata”:”challenge based learning”) AND (“Full Text & Metadata”:”higher learning”) OR (“Full Text & Metadata”:”university”))	250 (36.4%)
ScienceDirect	(“challenge based learning”) AND (“higher learning” OR “university”)	136 (19.8%)
Scopus	(TITLE-ABS-KEY (“challenge based learning”) AND (TITLE-ABS-KEY (“higher learning”) OR TITLE-ABS-KEY (“university”)))	31 (4.5%)
Total		686

A comprehensive literature review of CBL was conducted to determine whether this extended engagement with a CBL cycle had already been addressed. Four pertinent databases were selected: ACM Digital Library, IEEE Digital Library, ScienceDirect, and Scopus, to locate publications from 2015 to 2025. The search queries (Table 1) were intentionally broad, aiming to find any publication related to CBL and higher education.

From these results, 198 duplicates were removed, resulting in a total of 488 records to be screened. To expedite the screening process, an AI tool, ASReview LAB (V. 2.1.1) was used (Van de Schoot et al., 2020). As per van Dijk et al. (2023, p. 2), this tool uses titles and abstracts, and an “an active researcher-in-the-loop machine learning algorithm to rank the articles [...] probability of eligibility for inclusion.” Essentially, the tool is trained with relevant and irrelevant articles, iteratively improving its ability to identify relevant articles. A stopping criterion is set by the user (for example, finalizing the review after a certain number of consecutive irrelevant articles are displayed). Ideally, the optimal criterion would be the moment past which no more relevant articles are identified. Our stopping criterion was 10 irrelevant articles; however, since we were testing the tool, we extended the review to include another 30 articles, confirming that no new relevant articles surfaced. Figure 2 shows the Progress Recall chart, comparing relevant records found against a random approach, showcasing the efficacy of the methodology.

Figure 2

Progress Recall Chart From ASReview LAB



The criteria for screening relevant articles were: (1) relating to CBL and/or another active learning framework; (2) relating to higher education; and (3) analyzing empirical data. A total of 178 articles (titles and abstracts) were manually analyzed until the extended stopping criterion was reached. This resulted in a total of 98 articles marked as not relevant, 77 as relevant, and 314 unlabeled and assumed not relevant.

Out of the 77 remaining articles, the full text of each was analyzed, and the following exclusion criteria were applied: (1) article language not in English ($n = 2$); (2) not directly related to CBL ($n = 8$); (3) no empirical data analysis ($n = 7$); (4) total CBL cycle duration under 8 weeks or not disclosed ($n = 24$); and (5) full article text not available through the authors' institution ($n = 15$). This resulted in a total of 53 records excluded. The final number of included records was 24, which were further analyzed in full. Of these, 10 were deemed to actually address extended CBL engagements or longer CBL cycles, as listed in Table 2.

Although the 10 final selected studies addressed longer CBL cycles, none reported focusing on the specific skills related to the extended CBL cycle length. Our conclusion is that, while several studies address extended engagement in CBL, none focus solely on the development of skills that necessarily require longer timeframes and iterations. Moreover, we found no

study systematically extending engagement with a solution from a previous CBL cycle beyond the “Act” phase.

Table 2

Articles Selected for Longer CBL Engagements (n = 10)

Reference	Length
Binder et al. (2020)	2.5 years, 2 cycles, each 8+ weeks
Colombelli et al. (2021)	11 cycles, each 14 weeks
Colombelli et al. (2022)	11 cycles, each 14 weeks
Gonzalez-Hernandez et al. (2020)	4 semesters, each 19 weeks
Mora-Salinas et al. (2019)	2 cycles, each 18 weeks
Oliveira et al. (2024)	Two-year program and one-semester course; multiple cycles, up to 18 months
Romero-Yesa et al. (2023)	1 cycle, 14 weeks
Sanchez and Lamo (2024)	4 annual cycles, each subject 16+ weeks
Santos et al. (2018)	1 year
Zavala et al. (2023)	9 semesters; multiple cycles; each 16 weeks

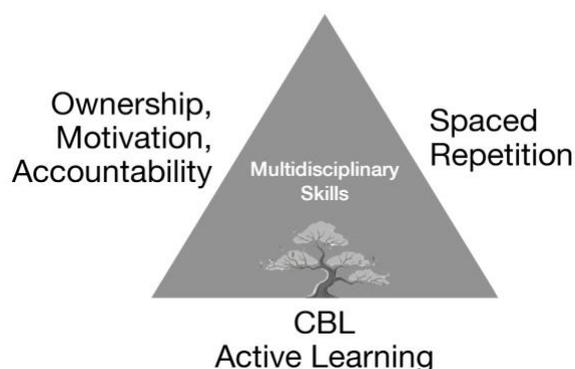
Methodology

We conducted an experiment with a cohort of 40 learners over 10 weeks. Each week (the “Bonsai Friday”) was dedicated *not* to their current ongoing CBL cycle, but rather to iterative improvements of a solution produced during a previous CBL cycle. At the beginning of the experiment, learners were given the opportunity to select a solution from a previous challenge (approximately two months long) regardless of whether they had not originally been part of the group that developed it. Ultimately, eight student-developed solutions were selected.

Our hypothesis is that this once-a-week approach may provide learners with opportunities to develop skills not typically cultivated during traditional CBL cycles. Figure 3 illustrates the Bonsai pedagogical approach, which integrates CBL with spaced repetition (Kang, 2016) and extends ownership, motivation, and accountability over a longer timeframe to foster multidisciplinary skills.

Figure 3

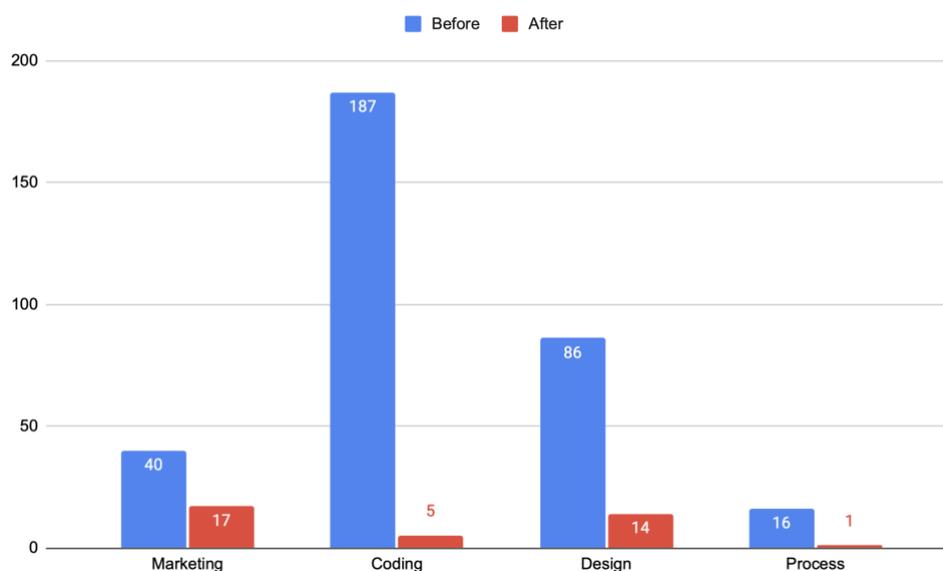
Pedagogical Triangle Illustrating the Integration of CBL and the Bonsai Approach. Each Side of the Triangle Represents a Core Component Contributing to Holistic Skill Development in Learners



To assess this, we used an internal list of skills covering several learning objectives. A panel of researchers ranked these skills, and those related to competencies requiring longer sustained effort ($n = 37$) were then used to create a questionnaire intended to assess learners' perceptions of their development in these skills. The skill categories were: Marketing (e.g., product management), Process (e.g., project management), Coding (e.g., working with developer tools), and Design (e.g., creating prototypes). Figure 4 shows a before-and-after ranking chart of skills by category, demonstrating that more Marketing and Design skills were deemed to require longer sustained effort.

Figure 4

Before-and-After Ranking of Skills by Category, Illustrating the Proportional Increase in Marketing and Design Skills Identified As Requiring Longer Sustained Effort



The questionnaire, based on the list of 37 skills, included 29 Likert-scale questions as well as open-ended questions. Table 3 presents some examples and responses. Related questions were grouped into the following sections: (1) general/introduction, (2) design patterns, (3) visual consistency and design, (4) developer tools, (5) entrepreneurship, (6) inclusivity and accessibility, (7) product management, (8) engagement, and (9) revisiting a past CBL solution. Each section was introduced by a reflective question with an open-ended response, intended not only to gather qualitative answers but also to prime respondents, allowing them to answer the questions more thoughtfully and with less influence from environmental contexts (Smith & Vela, 2001).

Table 3*Examples of Questionnaire Questions and Possible Answers*

Question	Answers (Likert scale)
I'm more effective at communicating through postings, presentations, marketing materials	Completely Disagree (1), Disagree (2), Neutral (3), Agree (4), Completely Agree (5), Not Applicable (6)
I'm better at applying best practices in app development.	Completely Disagree (1), Disagree (2), Neutral (3), Agree (4), Completely Agree (5), Not Applicable (6)
I'm better at detecting logic flaws, interface issues and performance issues using an IDE.	Completely Disagree (1), Disagree (2), Neutral (3), Agree (4), Completely Agree (5), Not Applicable (6)
I'm better at implementing accessibility resources in my apps.	Completely Disagree (1), Disagree (2), Neutral (3), Agree (4), Completely Agree (5), Not Applicable (6)
I'm better at defending user's needs based on research and user feedback.	Completely Disagree (1), Disagree (2), Neutral (3), Agree (4), Completely Agree (5), Not Applicable (6)
How would you rate your overall satisfaction with the opportunity to revisit a project from a previous CBL cycle?	Very dissatisfied (1), Somewhat dissatisfied (2), Neutral (3), Satisfied (4), Very satisfied (5)
Describe moments when you participated in making important decisions related to visual consistency or brand identity.	Open-ended

From a quantitative standpoint, the median value for most questions was 4 or higher on the Likert scale, indicating overall net positive results. Notable exceptions were the questions listed (paraphrased for brevity) in Table 4, which included three neutral results and two very positive results. The neutral results addressed accessibility, privacy, and the sustainability tripod (i.e., the economic, social, and environmental pillars for organizations that seek sustainable development practices). Although all these areas are extremely relevant, it is understandable that they are not generally priorities when building prototype solutions. The two most positive results were associated with ownership, accountability, and autonomy. Although Marketing and Design skills were previously identified as most likely to require longer sustained effort for improvement, they did not emerge as outliers.

Table 4*Selected Questionnaire Items With Outlier Median Likert Scale Responses*

Question	Median (Likert scale)
Implementing accessibility features	3.5
Implementing user privacy protection features	3
Regarding the concepts of the "sustainability tripod"	3
Having autonomy to make decisions and propose ideas	5
Assuming responsibility for the project's results even when not directly requested	4.5

Some of the notable responses, including open-ended ones, indicated that learners faced several significant challenges and learning opportunities, such as: "selling" their solutions to real potential customers or investors; revisiting and refactoring existing codebases, particularly when team members changed; setting priorities, adjusting roadmaps, and coordinating communication and work within their teams, especially given the need to balance short timeframes (one day per week) with ambitious goals; and switching to a different project at the end of a work week.

Recommendations

Based on questionnaire data collected and our direct observations, we propose the following recommendations to enhance the effectiveness of the Bonsai approach:

- (1) Project selection directly affects continuity and efficiency. We recommend choosing projects in which at least one team member has prior knowledge or previous involvement, in order to facilitate onboarding, ensure continuity, and avoid refactoring. Furthermore, switching teams between cycles should be strongly discouraged.
- (2) Refactoring or rebuilding is often favored over pursuing incremental improvements. Prioritize targeted enhancements, novel features, and user-driven refinements, reserving complete rebuilds for situations where they are essential and directly support project goals or long-term maintainability.
- (3) Focus on achievable goals within the available time (one day per week). Prioritize tasks and concentrate on the most impactful bugs, usability issues, or feature requests.
- (4) Involve real users, industry partners, or community members in feedback and validation processes. Encourage teams to test their solutions with actual users and iterate based on real-world feedback, not just theoretical improvements. However, given the limitation of working on the project only once a week, scheduling user testing may be challenging.

Conclusions, Limitations, and Future Work

Based on our direct experience and questionnaire responses, we conclude that the Bonsai approach did provide learners with opportunities to develop a distinct set of competencies, particularly in relation to learners' ownership and accountability for their proposed solutions, beyond merely delivering them at the end of a traditional CBL cycle. Moreover, we measured an overall positive impact across all skillset categories, which supports the hypothesis that the impact of the CBL methodology can be intentionally extended beyond its cycle.

These findings suggest that the Bonsai approach does, indeed, expand the educational value of CBL and enables the development of a distinct set of competencies with reduced overall time investment, while emulating some of the complexities found in real-world professional environments.

Our experiment was conducted with a cohort of 40 learners over 10 weeks. A larger sample size and varied timeframes would likely yield more robust conclusions. Moreover, as this represents the initial phase of an ongoing experiment, the results cannot be generalized. It is also important to observe that the authors are directly involved with the learners and the application of the CBL approach, which may introduce researcher bias.

For future work, we are conducting two additional interventions during CBL cycles and introducing modifications. Previous observations indicated that holding sessions late in the week can reduce focus and productivity due to fatigue; therefore, we are currently experimenting with Mondays instead of Fridays. The new "Bonsai Mondays" are intended to help prevent diminished outcomes. We plan to run two CBL cycles in parallel with Bonsai Mondays, one lasting 12 weeks and the other 8 weeks, with results again assessed by questionnaires. Additionally, we are seeking other cohorts willing to adopt this approach, in order to expand the sample size and enable more robust conclusions.

Acknowledgments

The authors express their heartfelt appreciation for the Apple Developer Academy | PUC-Rio learners, not only for their valuable contribution to our research but also for inspiring our daily appreciation of their growth in academic and professional careers as well as personal journeys.

The preparation of this article was supported by Brazil's Ministry of Science, Technology and Innovation (MCTI), with resources from Law No. 8.248/1991 (Information Technology Law), Process No. 01245.020820/2023-11, Agreement TPA/195/SOFTEX/PUC-Rio, dated November 27, 2023.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

This paper acknowledges the use of AI-assisted technologies in the writing process. These tools have been utilized to enhance the language and clarity of the manuscript, as well as to provide translations related to the questionnaire applied during the research, which was done in Portuguese. AI was also used in the literature review to make the process more efficient by using machine learning through ASReview LAB, an academic tool built for such purpose and validated by van Dijk et al. (2023), as explained in the methodology. The authors strongly reiterate their complete control over and responsibility for the final content presented in the manuscript. All use of such technologies has been done with ethical care to make sure any tools or methods complement and support the scholarly rigor that a research process requires.

References

- Binder, F. V., Albuquerque, R., Reinehr, S., & Malucelli, A. (2020, June). Innovation and active learning for training mobile app developers. In *Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering: Software Engineering Education and Training* (pp. 151-161).
- Cardador, D., Teixeira, B., Pereira, M., Rodrigues, L., Gama, C., Ladeira, R., & Nasser, R. (2023, October). Bridging the gap: an extended challenge-based learning framework for university-industry collaboration. In *International conference on technological ecosystems for enhancing multiculturalism* (pp. 863-873). Singapore: *Springer Nature Singapore*.
- Colombelli, A., Loccisano, S., Panelli, A., Pennisi, O., & Serraino, F. (2021). Challenge based learning as a practice for engineering education to develop students' entrepreneurial mindset. In *SEFI 2021, 49th Annual conference* (pp. 761-776).
- Colombelli, A., Loccisano, S., Panelli, A., Pennisi, O. A. M., & Serraino, F. (2022). Entrepreneurship education: The effects of challenge-based learning on the entrepreneurial mindset of university students. *Administrative Sciences*, 12(1), 10.
- Galdames-Calderón, M., Stavnskær Pedersen, A., & Rodriguez-Gomez, D. (2024). Systematic review: revisiting challenge-based learning teaching practices in higher education. *Education Sciences*, 14(9), 1008.
- Gonzalez-Hernandez, H. G., Cantu-Gonzalez, V., Mora-Salinas, R. J., & Reyes-Avenidaño, J. A. (2020, April). Challenge-based learning and traditional teaching in automatic control engineering courses: A comparative analysis. In *2020 IEEE Global Engineering Education Conference (EDUCON)* (pp. 792-798). IEEE.
- Kang, S. H. (2016). Spaced repetition promotes efficient and effective learning: Policy implications for instruction. *Policy Insights from the Behavioral and Brain Sciences*, 3(1), 12-19.
- Mora-Salinas, R., Torres, C. R., Castillo, D. H., & Rodriguez-Paz, M. X. (2019, April). The i-semester experience: Undergraduate challenge based learning within the automotive industry. In *2019 IEEE Global Engineering Education Conference (EDUCON)* (pp. 505-509). IEEE.
- Nichols, M., Cator, K., & Torres, M. (2016). Challenge Based Learner User Guide. *Digital Promise*.
- Oliveira, L., Araújo, C., & Castillo, L. (2024, October). A Toolkit for Promoting a Learning Innovation Safe Space (LISS) in Computing Higher Education. In *2024 IEEE Frontiers in Education Conference (FIE)* (pp. 1-8). IEEE.
- Romero-Yesa, S., Fonseca, D., Aláez, M., & Amo-Filva, D. (2023). Qualitative assessment of a challenge-based learning and teamwork applied in electronics program. *Heliyon*, 9(12).

- Sanchez, M. Á., & Lamo, P. (2024). Bridge the Gap: Using Challenge-Based Learning to Connect University and Industry. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*. [IEEE Magazine Ibero-American Journal of Learning Technologies.]
- Santos, A., Sales, A., Fernandes, P., & Kroll, J. (2018, May). Challenge-based learning: a Brazilian case study. In *Proceedings of the 40th International Conference on Software Engineering: Companion Proceedings* (pp. 155-156). Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic bulletin & review*, 8(2), 203-220.
- Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of business research*, 104, 333-339.
- Van de Schoot, R., de Bruin, J., Schram, R., Zahedi, P., Izadinia, M., Farahmand, H., van Dijk, A., Winter, S., van Rooij, F., de Vries, C., de Herder, J., Heyvaert, M., van den Heuvel, E., & de Boer, F. (2020). *ASReview: Active learning for systematic reviews* [Computer software]. Zenodo. <https://doi.org/10.5281/zenodo.3345592>
- van Dijk, S. H., Brusse-Keizer, M. G., Bucsán, C. C., van der Palen, J., Doggen, C. J., & Lenferink, A. (2023). Artificial intelligence in systematic reviews: promising when appropriately used. *BMJ open*, 13(7), e072254.
- Zavala, A., Cuevas-Ortuño, J., Cedeño, J. R. A., Araos, A. P., & de Luna, M. A. (2023, June). Integrating companies and higher education in the teaching-learning process of lean thinking using challenge-based learning. In *2023 ASEE Annual Conference & Exposition*.