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Multidisciplinary project-based learning and teaching in universities: Does it work?

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ABSTRACT

CONTEXT

Multidisciplinary practices can offer myriad benefits. These might explain the growing interest in multidisciplinary education, like that which is project-based.

PURPOSE

This study ascertains whether multidisciplinary project-based learning and teaching in universities work.

METHOD

A systematic scoping review was conducted to identify studies with empirical evidence of multi-disciplinary learning or teaching. A total of 58 publications met the inclusion criteria and were analysed.

OUTCOMES

The publications demonstrated varied interpretations of multidisciplinary project-based learning and teaching. Similarly, evaluation strategies were diverse. Despite this, multidisciplinary project-based learning and teaching were typically described as beneficial. However, relatively few publications presented research designs that can empirically substantiate this claim.

CONCLUSION

The findings of this study highlight two points. First, given the varied understandings of multidisciplinary project-based learning and teaching in universities, there is considerable opportunity for a theoretically-informed scholarship to clarify what it is and what it is not. Second, given the relative dearth of empirical research to evaluate multidisciplinary project-based learning and teaching in universities, there is a need for empirical research to verify who it benefits, how, why, as well as the unintended consequences that might arise.

KEYWORDS

Multidisciplinary; project-based; learning and teaching; university; education

Introduction

Multidisciplinary project-based learning and teaching has attracted increasing interest in higher education. It involves different disciplines in addressing an ill-defined, real-world issue to provoke critical thinking and practical experience among students (Carrió et al., 2016). As Handrianto and Rahman (2019, p. 111) explained:

> *[It is] a student-centered learning approach, in the form of an investigation, involving decision-making process based on data analysis, collaboration, product-oriented and involving document preparation… [It] is a teaching approach because it can be used by teachers to deliver syllabus based on predetermined learning outcomes… [It is also] a learning approach because it is based on theories of learning such as constitutionalism and also learning through experience.*

Multidisciplinary project-based learning and teaching encourages team building via activities on common problems (Hersam et al., 2004). Students address these problems by collaborating and integrating their skills (Biasutti & El-Deghaidy, 2015) – skills that industry values (Faludi & Gilbert, 2019; Pierrakos et al., 2010; Redshaw & Frampton, 2014). As such, it is assumed that mimicking these experiences at university will 'simulate workplace challenges' (Bentley, 2018, para. 15) that will provide students with strong skillsets to prepare them for their chosen industry.

However, multidisciplinary project-based learning and teaching is understood in different ways. For instance, the multidisciplinary aspect might be demonstrated by the involvement of: academic staff from different schools; academic staff who represent different discipline specialities; and/or students studying different degrees. Similarly, project-based learning and teaching is interpreted differently. It can involve (a)synchronous activities with different student cohorts, simultaneously or consecutively.

Despite interest in multidisciplinary project-based learning and teaching, whether it makes a positive difference is yet to be determined. As such, this systematic scoping review clarifies whether multidisciplinary project-based learning and teaching in universities is beneficial.

Method

A protocol was developed, specifying (PRISMA-ScR; Tricco et al., 2018): the population of interest – namely, universities, irrespective of geographical location; the phenomenon of interest – multidisciplinary efforts; as well as the outcomes – namely, the use of project-based learning and teaching, the associated effects, and the factors that helped or hindered it. Given their relevance, the following academic databases were systematically searched to identify relevant refereed publications: Academic Search Complete; Art & Architecture Complete; Business Source Complete; CINAHL Plus with Full Text; Communication Abstracts; Computers & Applied Sciences Complete; Education Research Complete; Health Business Elite; Health Source: Nursing/Academic Edition; Humanities International Complete; Psychology and Behavioral Sciences Collection; APA PsycINFO; and SocINDEX with Full Text. The databases were searched in October 2021 by searching for the following terms within publication title and/or abstract: cross-disciplinary or crossdisciplinary or inter-disciplinary or interdisciplinary or multi-disciplinary or multidisciplinary or trans-disciplinary or transdisciplinary; and "challenge-based learning" or "challenge-based teaching" or "inquiry-based learning" or "inquiry-based teaching" or PBL or PBT or "problem-based learning" or "problem-based teaching" or "project-based learning" or "project-based teaching"; and college* or facult* or post-graduate* or postgraduate* or tertiary or under-graduate* or undergraduate* or universit*. This search served to identify 236 publications. A publication was included in this review if it: presented findings on multidisciplinary project-based learning and teaching in universities; represented a research publication; was authored by a named author; was published in English; did not represent a systematic, narrative, or literature review or meta-analysis; and/or did not represent a conceptual, theoretical, or methodological publication. Three authors independently screened the titles and abstracts of the 236 publications, compared their decisions, and reconciled differences. Following this, 58 publications remained. Five authors reviewed these publications, extracting content regarding: publication details; study aim; the disciplines represented; reference to cross-disciplinary, multidisciplinary, interdisciplinary, or transdisciplinary efforts; how project-based learning and/or teaching was understood; key

findings; as well as author-identified limitations and future research opportunities. Two authors reported on key findings in narrative form.

Results

Most of the projects presented in the publications involved: students (59%); students and academic staff (26%); or academic staff, alone (7%). Most of the publications spoke of multidisciplinary efforts (66%), while fewer reported on interdisciplinary (26%), cross-disciplinary (5%), or transdisciplinary efforts (3%). The disciplines typically represented in the publications included: engineering and design (34%); medicine and nursing (21%); and science (17%). Disciplines that did not feature prominently included: the arts, language, and literature (8%); as well as business and information technology (7%). Yet, 10% of the publications did not explicitly clarify the disciplines that were represented in the study. Multidisciplinary project-based learning and teaching was largely found to be beneficial. However, its challenges were also recognised, as the following sections demonstrate.

Positive Effects

Multidisciplinary project-based learning and teaching can foster 'a truly active learning process' among students (Cargnin-Stieler et al., 2019, p. 23). It can offer students the opportunity to embark on their own learning by creating interdisciplinary solutions to discipline-related problems. Similarly, multidisciplinary project-based learning and teaching can offer students opportunities to: find 'satisfaction… [in] working together in a setting that can mimic professional environments… recognize problems, causes, and solutions… [and] figure out how to move from the problem to a solution' (Hutchison, 2016, p. 9). Additionally, multidisciplinary project-based learning and teaching can result in contextually-appropriate solutions, while equipping students with knowledge as well as technical, interdisciplinary, critical thinking, and interpersonal skills (Jansson et al., 2015; Kimmons & Spruiell, 2005; Kohn Rådberg et al., 2020; Kovalyova et al., 2016; Munezero & Bekuta, 2016; Tatzl et al., 2012). For instance, Keenahan and McCrum (2021) found engineering and architectural students developed a better appreciation for each other's discipline, while others found multidisciplinary project-based learning and teaching fostered students' problem-solving skills (Guo et al., 2014; McCrum, 2017). Furthermore, there is evidence that the benefits associated with multidisciplinary project-based learning and teaching can be sustained (Alley et al., 2018; Carrió et al., 2016).

Multidisciplinary project-based learning and teaching has also helped to 'increase… engagement with course material' (Cummings & Cummings, 2021, p. 7). It can promote participation in online communication (Mallinson, 2018; Nerantzi, 2012) as well as feedback mechanisms (Lockrey & Bissett Johnson, 2013).

Beyond discipline-specific knowledge, multidisciplinary project-based learning and teaching can enable students to develop ethical attitudes, with a greater appreciation for the social dimensions of their disciplines (Biasutti & El-Deghaidy, 2015; Cobb et al., 2008; Koch & Zumbach, 2002; Kuo et al., 2019; Malheiro et al., 2019). This might partly follow opportunities for students to 'engag[e with]… subject matter experts, and focus… on real-world scenarios' (Biello et al., 2022, p. 64). For instance, research suggests that students value the approach, which inculcates knowledge on sustainability (Chau, 2007; Kricsfalusy et al., 2018; Tasdemir & Gazo, 2020). As such, multidisciplinary project-based learning and teaching offers benefits that a single discipline is unable to provide (Hey et al., 2007; Nelson et al., 2021; Vogler et al., 2018).

Multidisciplinary project-based learning and teaching can also benefit academic staff. It offers ways to collect 'stable and reliable information' from students to evaluate teaching, which 'can be used to improve the curriculum as well as the performance of the participating teachers' (Krantz-girod et al., 2004, p. 131).

Challenges

The benefits associated with multidisciplinary project-based learning and teaching can be hindered by myriad factors. These include the learning environment (Kitzes et al., 2007; Pierrakos et al.,

2010; Redshaw & Frampton, 2014); specifically, a sense of psychological safety, social interaction, attitudes toward multidisciplinary project-based learning and teaching, and policy (Broussard et al., 2007; Colombari & Neirotti, 2021). Furthermore, the benefits can also be shaped by student needs and preferences. For example, students who are new to higher education might require 'greater direction over the topic of study and the constitution of interdisciplinary groups, even if this means partially limiting student autonomy – a key philosophical element of the approach' (Harmer & Stokes, 2016, p. 543).

The benefits of multidisciplinary project-based learning and teaching can also come at a cost. For instance, it can increase the workload of academic staff, as they develop materials, organise their approach, and evaluate student development (Hassan et al., 2015; Jacques, 2017).

Discussion

This systematic scoping review suggests four key points. First, multidisciplinary project-based learning and teaching manifests and is evaluated in varied ways in higher education. Second, it can benefit both students and academic staff. Third, it can be challenging to implement. And fourth, given the varied understandings of multidisciplinary project-based learning and teaching, and the varied ways it was examined, there is considerable opportunity to clarify what works for whom, when, and why.

Despite the value of these findings, two methodological limitations warrant mention. First, given the disparate terms that denote multidisciplinary project-based learning and teaching, the search strategy might not have identified all relevant publications. Second, due to publication bias, the findings are likely to be positively skewed.

Conclusion

Despite the aforesaid limitations, the findings from this systematic scoping review have implications for scholars and educators. For scholars, they offer a firm foundation for further research to clarify what multidisciplinary project-based learning is (and is not), as well as the approaches that optimise impact. For educators, the findings highlight the value of multidisciplinary project-based learning and the need to clarify how it is designed, implemented, and evaluated.

References

Alley, W. D., Burns, C., Hartman, N. D., Askew, K., & Mahler, S. A. (2018). 3 for the price of 1: Teaching chest pain risk stratification in a multidisciplinary, problem-based learning workshop [Article]. *Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health*, *19*(3), 613-618. https://doi.org/10.5811/westjem.2017.12.36444

Bentley, D. (2018, 26th Jul.). *How universities can make graduates employable with connections to industry*. The Conversation. Retrieved 27th Feb. from https://theconversation.com/how-universities-can-make-graduates-employable-with-connections-to-industry-91838

Biasutti, M., & El-Deghaidy, H. (2015). Interdisciplinary project-based learning: An online wiki experience in teacher education [Article]. *Technology, Pedagogy & Education*, *24*(3), 339-355. https://doi.org/10.1080/1475939X.2014.899510

Biello, S., Yoss, S., Walker, E. R., Druss, B., & Lang, D. L. (2022). Addressing public mental health challenges: A mixed-methods evaluation of problem-based learning [Article]. *Pedagogy in Health Promotion*, *8*(1), 59-66. https://doi.org/10.1177/2373379920944963

Broussard, S. R., La Lopa, J. M., & Ross-Davis, A. (2007). Synergistic knowledge development in interdisciplinary teams [Article]. *Journal of Natural Resources & Life Sciences Education*, *36*(1), 129-133. https://doi.org/10.2134/jnrlse2007.361129x

Cargnin-Stieler, M., Malheiro, M. T., Alves, A. C., Lima, R. M., & Teixeira, M. C. M. (2019). Learning calculus through PBL in an industrial engineering and management program - A seven-year study [Article]. *Advances in Engineering Education*, *7*(3), 1-28. http://ezproxy.uws.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=140930535&site=ehost-live&scope=site

Carrió, M., Agell, L., Baños, J. E., Moyano, E., Larramona, P., & Pérez, J. (2016). Benefits of using a hybrid problem-based learning curriculum to improve long-term learning acquisition in undergraduate biology education [Article]. *FEMS Microbiology Letters*, *363*(15), 1-7. https://doi.org/10.1093/femsle/fnw159

Chau, K. W. (2007). Incorporation of sustainability concepts into a civil engineering curriculum [Article]. *Journal of Professional Issues in Engineering Education & Practice*, *133*(3), 188-191. https://doi.org/10.1061/(ASCE)1052-3928(2007)133:3(188)

Cobb, C. L., Agogino, A. M., Beckman, S. L., & Speer, L. (2008). Enabling and characterizing twenty-first century skills in new product development teams [Article]. *International Journal of Engineering Education*, *24*(2), 420-433. http://ezproxy.uws.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=32040893&site=ehost-live&scope=site

Colombari, R., & Neirotti, P. (2021). Closing the middle-skills gap widened by digitalization: how technical universities can contribute through Challenge-Based Learning [Article]. *Studies in Higher Education*, 1-16. https://doi.org/10.1080/03075079.2021.1946029

Cummings, C. M., & Cummings, T. M. (2021). Teaching Non-Majors Hydroponics: PBL in Higher Education [Article]. *College Teaching*, *69*(1), 1-8. https://doi.org/10.1080/87567555.2020.1791036

Faludi, J., & Gilbert, C. (2019). Best practices for teaching green invention: Interviews on design, engineering, and business education [Article]. *Journal of Cleaner Production*, *234*, 1246-1261. https://doi.org/10.1016/j.jclepro.2019.06.246

Guo, Y., Zhang, S., Ritter, A., & Man, H. (2014). A case study on a capsule robot in the gastrointestinal tract to teach robot programming and navigation [Article]. *IEEE Transactions on Education*, *57*(2), 112-121. https://doi.org/10.1109/TE.2013.2281025

Handrianto, C., & Rahman, M. A. (2019). Project based learning: A review of literature on its outcomes and implementation issues. *Linguistics, Literature and English Teaching Journal*, *8*(2), 110-129.

Harmer, N., & Stokes, A. (2016). "Choice may not necessarily be a good thing": Student attitudes to autonomy in interdisciplinary project-based learning in GEES disciplines [Article]. *Journal of Geography in Higher Education*, *40*(4), 531-545. https://doi.org/10.1080/03098265.2016.1174817

Hassan, H., Dominguez, C., Martinez, J.-M., Perles, A., Capella, J.-V., & Albaladejo, J. (2015). A multidisciplinary PBL robot control project in automation and electronic engineering [Article]. *IEEE Transactions on Education*, *58*(3), 167-172. https://doi.org/10.1109/TE.2014.2348538

Hersam, M. C., Luna, M., & Light, G. (2004). Implementation of interdisciplinary group learning and peer assessment in a nanotechnology engineering course [Article]. *Journal of Engineering Education*, *93*(1), 49-57. https://doi.org/10.1002/j.2168-9830.2004.tb00787.x

Hey, J., Van Pelt., A., Agogino, A., & Beckman, S. (2007). Self-reflection: Lessons learned in a new product development class [Article]. *Journal of Mechanical Design*, *129*(7), 668-676. https://doi.org/10.1115/1.2722781

Hutchison, M. (2016). The empathy project: using a project-based learning assignment to increase first-year college students' comfort with interdisciplinarity [Article]. *Interdisciplinary Journal of Problem-based Learning*, *10*(1), 1-12. https://doi.org/10.7771/1541-5015.1580

Jacques, S. (2017). A pedagogical intensive collaborative electric go-kart project [Article]. *International Journal of Engineering Pedagogy*, *7*(4), 117-134. https://doi.org/10.3991/ijep.v7i4.7408

Jansson, S., Söderström, H., Andersson, P. L., & Nording, M. L. (2015). Implementation of Problem-Based Learning in Environmental Chemistry [Article]. *Journal of Chemical Education*, *92*(12), 2080-2086. https://doi.org/10.1021/ed500970y

Keenahan, J., & McCrum, D. (2021). Developing interdisciplinary understanding and dialogue between engineering and architectural students: design and evaluation of a problem-based learning module [Article]. *European Journal of Engineering Education*, *46*(4), 575-603. https://doi.org/10.1080/03043797.2020.1826909

Kimmons, J. V., & Spruiell, P. R. (2005). Using problem-based learning in a multidisciplinary setting [Article]. *Clothing & Textiles Research Journal*, *23*(4), 385-395. https://doi.org/10.1177/0887302X0502300418

Kitzes, J. A., Savich, R. D., Kalishman, S., Sander, J. C., Prasad, A., Morris, C. R., & Timm, C. (2007). Fitting it all in: Integration of 12 cross-cutting themes into a School of Medicine curriculum [Article]. *Medical Teacher*, *29*(5), 437-442. https://doi.org/10.1080/01421590701288564

Koch, S. C., & Zumbach, J. (2002). The use of video analysis software in behavior observation research: Interaction patterns in task-oriented small groups [Article]. *Forum: Qualitative Social Research*, *3*(2), 208-224. http://ezproxy.uws.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=sih&AN=32571107&site=ehost-live&scope=site

Kohn Rådberg, K., Lundqvist, U., Malmqvist, J., & Hagvall Svensson, O. (2020). From CDIO to challenge-based learning experiences – Expanding student learning as well as societal impact? [Article]. *European Journal of Engineering Education*, *45*(1), 22-37. https://doi.org/10.1080/03043797.2018.1441265

Kovalyova, Y. Y., Soboleva, A. V., & Kerimkulov, A. T. (2016). Project based learning in teaching communication skills in English as a foreign language to engineering students [Article]. *International Journal of Emerging Technologies in Learning*, *11*(4), 153-156. https://doi.org/10.3991/ijet.v11i04.5416

Krantz-girod, C., Bonvin, R., Lanares, J., Cueánot, S., Feihl, F., Bosman, F., & Waeber, B. (2004). Stability of repeated student evaluations of teaching in the second preclinical year of a medical curriculum [Article]. *Assessment & Evaluation in Higher Education*, *29*(1), 123-133. https://doi.org/10.1080/0260293032000158207

Kricsfalusy, V., George, C., & Reed, M. G. (2018). Integrating problem- and project-based learning opportunities: assessing outcomes of a field course in environment and sustainability [Article]. *Environmental Education Research*, *24*(4), 593-610. https://doi.org/10.1080/13504622.2016.1269874

Kuo, H.-C., Tseng, Y.-C., & Yang, Y.-T. C. (2019). Promoting college student's learning motivation and creativity through a STEM interdisciplinary PBL human-computer interaction system design and development course [Article]. *Thinking Skills & Creativity*, *31*, 1-10. https://doi.org/10.1016/j.tsc.2018.09.001

Lockrey, S., & Bissett Johnson, K. (2013). Designing pedagogy with emerging sustainable technologies [Article]. *Journal of Cleaner Production*, *61*, 70-79. https://doi.org/10.1016/j.jclepro.2013.05.005

Malheiro, B., Silva, M. F., Ferreira, P., & Guedes, P. (2019). Learning engineering with EPS@ISEP: developing projects for smart sustainable cities [Article]. *International Journal of Engineering Pedagogy*, *9*(4), 33-49. https://doi.org/10.3991/ijep.v9i4.10259

Mallinson, C. (2018). Technology-enhanced project-based learning: A platform for graduate student research and outreach on campus and in the community [Article]. *Journal of English Linguistics*, *46*(3), 229-245. https://doi.org/10.1177/0075424218783447

McCrum, D. P. (2017). Evaluation of creative problem-solving abilities in undergraduate structural engineers through interdisciplinary problem-based learning [Article]. *European Journal of Engineering Education*, *42*(6), 684-700. https://doi.org/10.1080/03043797.2016.1216089

Munezero, M. D., & Bekuta, B. K. (2016). Benefits and challenges of introducing a blended project-based approach in higher education: Experiences from a Kenyan university [Article]. *International Journal of Education & Development using Information & Communication Technology*, *12*(2), 206-218. http://ezproxy.uws.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=117851882&site=ehost-live&scope=site

Nelson, R., Marone, V., Garcia, S. A., Yuen, T. T., Bonner, E. P., & Browning, J. A. (2021). Transformative practices in engineering education: The embedded expert model [Article]. *IEEE Transactions on Education*, *64*(2), 187-194. https://doi.org/10.1109/TE.2020.3026906

Nerantzi, C. (2012). A case of problem based learning for cross-institutional collaboration [Article]. *Electronic Journal of e-Learning*, *10*(3), 306-314. http://ezproxy.uws.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=87402968&site=ehost-live&scope=site

Pierrakos, O., Zilberberg, A., & Anderson, R. (2010). Understanding undergraduate research experiences through the lens of problem-based learning: Implications for curriculum translation [Article].

Interdisciplinary Journal of Problem-based Learning, *4*(2), 35-62. https://doi.org/10.7771/1541-5015.1103

Redshaw, C. H., & Frampton, I. (2014). Optimising inter-disciplinary problem-based learning in postgraduate environmental and science education: Recommendations from a case study. *International Journal of Environmental and Science Education*, *9*(1), 97-110.

Tasdemir, C., & Gazo, R. (2020). Integrating sustainability into higher education curriculum through a transdisciplinary perspective [Article]. *Journal of Cleaner Production*, *265*, 1-14. https://doi.org/10.1016/j.jclepro.2020.121759

Tatzl, D., Hassler, W., Messnarz, B., & Flühr, H. (2012). The development of a project-based collaborative technical writing model founded on learner feedback in a tertiary aeronautical engineering program [Article]. *Journal of Technical Writing & Communication*, *42*(3), 279-304. https://doi.org/10.2190/TW.42.3.f

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., . . . Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*, *169*(7), 467-473.

Vogler, J. S., Thompson, P., Davis, D. W., Mayfield, B. E., Finley, P. M., & Yasseri, D. (2018). The hard work of soft skills: Augmenting the project-based learning experience with interdisciplinary teamwork [Article]. *Instructional Science*, *46*(3), 457-488. https://doi.org/10.1007/s11251-017-9438-9

Universities Australia (2022). Built on bright ideas. A policy guide to Australia's future [online] . Retrieved from https://www.universitiesaustralia.edu.au/publication/built-on-bright-ideas/ [Accessed 12 July 2022].

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