Research-Based Education

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Definition

Research-based education, leaning on Elliott Seif's (2021) outstanding summary, is "a specific approach to classroom teaching that places less emphasis on teacher-centered learning of content and facts and greater emphasis on students as active researchers", preparing them to be lifelong inquirers and learners. Research-based education orients students' performance through five stages, beginning with active search for and then use of multiple resources in order to explore important, relevant and interesting questions and challenges that lead to clarification and identification of a personal research topic. Gradually, they "find, process, organize and evaluate information and ideas ... learn how to read for understanding, form interpretations, develop and evaluate hypotheses, and think critically and creatively". During this research process they can also understand how to generate contexts, setting a hierarchy of research questions. Through sharing the results, students are developing "communication skills through writing and discussion" (Seif 2021).

From a student's perspective it is common to talk about research-based education (also as inquiry-based learning, research-intensive learning), which "should help motivate them to become experts in their self-described field. And the more often a student gets a taste of what it feels like to be an expert, in however small a concept, the more they will want that feeling later on in life" (Wolpert-Gawron 2016). Again from a teacher's perspective, it is necessary to call the "other side" research or inquiry-based instruction or research-engaged teaching. From a complex educational and organizational culture perspective the overall framework is regularly designated as research-based environment.

Research-based education gradually consolidated as a well-founded methodological-didactical direction, developing special "teaching the teachers"-type courses, and came closer to citizen science initiatives, channeling open scientific crowdsource projects into higher education. This development could progressively improve lifelong learning, transforming its certain terrains to lifelong research (Z. Karvalics 2013). Lifelong research is an extension of research-based education, transplanting "research skills and academic productivity in a feasible and sustainable approach" to the post-university life of the former students (Himelhoch et al. 2015, 445). However, research-based education is not about supporting the reproduction of scientific reinforcements, nurturing new scholars – it is about producing scientifically literate generations from higher education.

Background

It is a common supposition that children are natural-born scientists, since the process by which children turn experience into knowledge is identical to the process that we call scientific knowledge, produced by scientists (Holt 1989 1989). An example of this thinking is described by Alison Gopnik (2012), who found that "young children, in their play and interactions with their surroundings, learn from statistics, experiments and from the actions of others in much the same way that scientists do" (Yaffe 2022, 10). Francis (2012) evaluates this popular approach as a mixture of truth and falsehood, as researchers' thinking has its sources not only in their natural curiosity and mental plasticity, but it is a learned skill. However, as Shanahan (2011) underlines it, science is not just a grown-up version of a child's curiosity.

> While children have the fertile beginnings, becoming a scientist requires that they learn and skillfully practice many abstract skills that are far from intuitive. When students struggle with scientific thinking later in life it isn't because they have unlearned or lost the ability, it's because they (for any number of reasons) did not get to take the next steps to developing those skills and understandings (Shanahan 2011).

This mission has never been completed in elementary and secondary schools. Basic disciplinary science education is a fundamental feature, sometimes with its advanced discovery-based forms which challenged and changed the traditional instruction-based pedagogical culture (Mirzoyan 2021). However, the research environment is simply simulated or emulated into talent management solutions and forms. Now, it is not the child prodigies or wunderkinds, but "child scientists" (McCartney 2011) are the best proofs that there would be several reasons to teach scientific literacy and research skills already to age groups of 12–18 and 8–12. When wanting to complete this unfulfilled mission, it is the role of higher education to provide and practice elementary research skills for all – from the birth of modern universities in the late 19th century.

In medieval universities science making was on the periphery. After the Humboldtian turn, "research (as a process of searching for truth) became a system-forming element of university education, since students, interacting with teachers, acquired not only formal knowledge, but also certain value imperatives that formed their professional vocation and personal position" (Islomovich 2021, 75). To be able to compose a dissertation became a ritual precondition of graduation, as a metaphor of an intellectual initiation process. Science today is apparently not a privilege of the small number of elected, outstanding people. Moreover, there are enormous differences between three different levels of research-based education practice.

The main goal of the introductory (typically undergraduate) level is to foster student awareness and motivation, making them familiar with scientific thinking, mediating research-related forms of literacy and skills. The outcome is some learnt elements of the scientific method, picking up as many abilities from the research literacy complex as students can. On the medium level, the challenge is to be able to use these skills, capacities, and sensitivities for an inquiry-based practice, solving a research problem while acquiring new disciplinary knowledge in a given field. It is nothing else than the rediscovery of existing scientific knowledge, while students are completing micro-research cycles and learning intensively. Finally, at a high level, the students can become producers of new scientific knowledge. Unfortunately, today this training philosophy is not a strict requirement for research-based education practitioners.

Healey and Jenkins (2018, 54) draw a distinction between four overlapping ways in which students may engage with research. The first one is the *research-led level*, where students learn about current disciplinary research. This is followed by (2) the *research-oriented level*, where they develop research skills; (3) the *research-based level*, where the focus is on undertaking research; and (4) the *research-tutored level*, where they engage in discussions on current research. These "stratifications" come into view in the same way in the most popular typology of citizen science, composed by Haklay (2012), reflecting the level of scientific profundity of personal involvement in research processes from the simple *crowdsource* logic, followed by *distributed intelligence* practices, reaching the *participatory science* stage, and finally the *extreme citizen science* projects, where full-value contribution is expected and required from the group members.

In order to reinvent the research-based education environment, it is necessary to accept that education and research are equally important and bridge divides between research and teaching staff. These staff members should excel in both research and teaching. Positive attitudes towards research by students should be strengthened among staff and students. Resources to do research must be available for students, among others by involving libraries in teaching information literacy to students. There should be opportunities and incentives for teachers for further development of their research-based teaching competence and excellence, including the creation of opportunities for dissemination of successful practices. This cannot be done without recognizing teaching excellence and monitoring the growth of research-based teaching. Inter alia, introducing an undergraduate student research award may help in achieving goals that can be solidified if there is more research initiated and financed on the nexus between teaching and research, as well as of research-based teaching and learning in particular (Dekker and Wolf 2016, 10–11).

Debate and criticism

The analysis of research-based education and learning became a popular scholarly field after the millennium. "More than half of the studies were published since 2010, [which] suggests an increasing interest in disseminating the outcomes of incorporating RBL [research-based learning] practices in Higher Education courses" (Camacho et al. 2017, 4192). However, in the forge of the discourse today is living dialogue, debate, and shared experience of the practitioners through textbooks, special reports, methodology exchange forms, blogposts, and comments. This semi-formal ecosystem of ideas gives account of the advantages and disadvantages of research-based methods.

Many teachers mention the greater interest of students during the whole learning and activity cycle, generating more attention, emphasis, engagement, and ambition, discussing the key topical issues in an open way. It is often highlighted that intensive problem-solving focus and the acquired teamwork routine prepares for real-world situations like few others. Practitioners recurrently testify that the retrieval, recall, and reuse of information in the afterlife is strongly supported by research-based forms of education, enhancing long-term knowledge retention (Lindsey et al. 2014).

The list of disadvantages begins with the ambiguous and shaky feedback. The lack of proper assessment creates confusion and anxiety, and the standardized testing performance is missing or poor quality. The risk of students' embarrassment and reluctance is high. Slow thinkers, introverted students, and the ones with learning disabilities are not prepared for the flexibility and freedom assigned to this kind of activity. A majority faces difficulties in collaboration, teamwork, and a culture of sharing results. Their overall readiness and responsibility are characteristically low. The lack of reinforcement flow is also a typical problem. The first steps can be attractive and alluring, but later, unravelling the higher skills of participants' than what is needed for, even an eager student quickly become bored. The lack of such skills can be undermining, and can easily frustrate the students. Unprepared teachers produce disorganized teaching, with vague requirements, and a lack of guidance and task personalization. The result is a sloppy classroom.

The methodology of research-based education was developed in multifarious ways by researchers and practitioners. The long-standing, literature-hunting desk research was stepwise enhanced by varied quantitative and interpretive disciplinary methods (Slater et al. 2015), and action research in education (Efron and Ravid 2017). One of the most intensive and engaging forms of action research is community-based research, which is "collaborative and change-oriented and finds its research questions in the needs of communities", combining "classroom learning with social action in ways that can ultimately empower community groups to address their own agendas and shape their own futures. At the same time, it emphasizes the development of knowledge and skills that truly prepare students for active civic engagement" (Strand et al. 2003, 1).

Methodologies were also enriched by disciplinary endeavors. As a part of the development of general art-based research methodologies (Leavy 2020), universities were early adapters, building the experiences fruitfully into their curricula, creating an independent field, art-based research in education (Cahnman-Taylor and Siegesmund 2017). Alongside the design thinking paradigm, its approaches and considerations were transferred easily to research-based education praxis, as design-based research in education (Philippakos et al. 2021).

The latest frontier is challenge-based research and learning. Challenges are for competing student groups to solve problems. Today it seems to be one of the most efficient and motivating frameworks for learning while solving real-world problems through research. This method develops "student transversal competencies, knowledge of sociotechnical problems, and collaboration with industry and community actors" in a versatile way (Gallagher and Savage 2020). This approach is obviously popular in *research-intensive universities*, where the increase of knowledge flow and the production of new knowledge across diverse disciplines are deeply embedded in the education practice (Njuguna 2015), thus directly creating value for society. There are mingled versions of these methods, too. It is easy to mix art-based platforms with other approaches, and design thinking regularly meets with challenge-based projects (Charosky et al. 2018).

Current forms of implementation in higher education

Healey and Jenkins (2018, 67) collected comparative examples of implemented policies and cases in different higher education institutions all over the world. The updated and improved list below also represents further possibilities of investigation to discover and apply new and new best practices, although there are not many venues where the organized exchange of experiences takes place.

Table 1. International RBE practices

Higher Education education provider	Institutional approach
University of Adelaide, Australia	Small group discovery experience
Dublin City University, Ireland	Challenge-based learning
Humboldt University, Berlin, Germany	Research-based education
Kingston University, London, UK	Promoting and reinforcing a research-based education environment to STEM undergraduate students
Leiden University, Netherlands	Fostering students' awareness of research
University of Lincoln, UK	Student as producer
Maastricht University Netherlands	Extending problem-based learning to research-based learning
McMaster University, Canada	Problem-based and inquiry-based learning
Miami University, US	Student as scholar
Massachusetts Institute of Technology, US	Undergraduate research opportunity program
Olin College of Engineering, US	Group project-based entrepreneurial engineering design projects
Quest University, Canada	Research-based education
Roskilde, Denmark	Problem-oriented project-based learning
University College, London, UK	Research-based education and the connected curriculum
University of Delaware, US	Providing a discovery-oriented environment
Carl von Ossietzky University, Oldenburg, Germany	Research-based teaching and learning as a guideline for developing various degree programs, modules, and individual courses.

The involvement and curriculum-based development of varied literacies also fruitfully supports the goals of research-based education. From these kinds of literacies, *information literacy* appeared early and became a fundamental one that is not restricted to textual information, but relates to digital content, data, and images; thus it is not a stand-alone concept, but overlaps with other literacies (CILIP 2018, 3).

Media literacy, especially in its critical from is similarly fundamental, as it focuses on trustworthy media content, and considers how messages are constructed (Funk et al. 2016).

The newest entry in this group of literacies is *data literacy*. According to one of its definitions, it aims at enabling individuals to access, assess, manage, handle, and use data (Calzada Prado and Marzal 2013, 126). Citizens' critical and active agency is paramount when society's datafication and decision-making, driven by algorithms, has become normalized. One of the enabling factors of data literacy is data citizenship that underlines critical and active agency that takes account of society's datafication and decision-making, driven by algorithms. It is divided into three components: (1) *Data thinking*, i.e. citizens' critical understanding of data collection and data economy; (2) *Data doing*, e.g. everyday engagements with data, including using and deleting it in an ethical way; (3) *Understanding the digital economy*, i.e. how algorithms work and who is funding social media platforms (Carmi et al. 2020, 10). Nevertheless, *visual literacy* (*visuacy*) can greatly help in providing confident and attractive representation of the used data.

Illustrating these new triggers of research-based education, the following table provides an overview of emblematic courses from leading universities. In the future, the number and plurality of these kinds of literacy-focused and data culture-related improvements will expectedly spread in higher education.

Table 2. International literacy practices

Higher education provider	Institutional approach
Rutgers University, US	Producing media literacy-based interventions for active involvement in creating secondary school substance abuse prevention messages.
Stanford University, US	Two curricula (Beyond the Bubble; Reading Like a Historian), based on media literacy and information literacy, and directed to contextualize and corroborate historical texts and stimuli.
University of Nebraska-Lincoln (UNL), Columbia University/ NASA, US	Supporting secondary school students to use authentic climate models and understand epistemic dimensions of climate science, relying on data literacy.

By relying on inquiry-based and research-intensive learning, supported by varied literacies, research-based education is meant to provide engaging research opportunities that are well incorporated in learning activities and well supervised by teaching staff (Van der Rijst 2017). This quality research-based education promises varied types of transformative learning experience for a wide range of students. It will play a growing role in education and, simultaneously, in the production of new scientific knowledge, while building more future-proof universities. Research-based education is not just a way to refresh education practice with stronger student motivation, but also outlines a new, community-driven culture of doing science.

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