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‘As I would do in my own research’: A multiple-case study of faculty members’ undergraduate research designs in research-intensive universities

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‘As I would do in my own research’: A multiple-case study of faculty members’ undergraduate research designs in research-intensive universities

Undergraduate research (UR) is regarded as an impactful instructional practice, but implementing it in the curriculum is challenging. Faculty members’ approaches to the design of UR are under-explored due to the scarcity of studies that situate practices in both the curricular contexts and the concept of the research-teaching nexus. This multiple-case study investigated faculty members’ approaches to UR in four curricula in two research-intensive universities in Hong Kong. Document review and semi-structured interviews revealed five approaches to UR: project-based, process-based, lab-based, scenario-based, and research community-based approaches. Particularly, the scenario-based and research community-based approaches complemented the current typologies. Another contribution of this study is the identification of nuanced differences in the adoption of the approaches. Faculty members perceiving reciprocal research-teaching nexus at both departmental and personal levels, and viewing UR holistically, tended to connect students with their own research experiences. In contrast, those who only acknowledged the research-teaching nexus at a departmental level were unlikely to create such a connection. Meanwhile, concerns over curricular coherence and ethics were also discussed. The implications include creating a more transparent process of curriculum design and facilitating students’ understanding of their contributions to the research community. It would also be useful to engage faculty members more fully in curriculum planning to enhance the coherence of students’ research experiences.

Keywords: undergraduate research; research-teaching nexus; research-based learning; faculty members; authenticity

Introduction

In a world full of uncertainties, learning through conducting research becomes impactful, as students learn to evaluate the value of knowledge and apply it across contexts (Harland and Wald 2018). UR can be seen as a form of experiential learning, which has been championed in many universities, and learning by doing has been viewed as an effective pedagogy to consolidate the acquired knowledge with practical applications (Coker et al. 2017; Zimbardi and Myatt 2014). Ideally, a research-based curriculum can provide students with opportunities to conduct research, learn the latest development in the field, develop research skills, and contribute to the university's research agenda (Brew 2010). Among examples of research-based curriculum worldwide (e.g. Brew 2010; Fung 2017; Ngo and Asem 2007), the 'connected framework' (Fung 2017) situates research at the core of the curriculum, specifying that student learning 'should reflect the kinds of active, critical, and analytic enquiry undertaken by researchers' (p. 20).

Numerous challenges have been reported regarding implementing research-based learning, for example, an increased workload for faculty members and students (Moore, Hvenegaard, and Wesselius 2018) and difficulties in assessing research skills (Hughes 2019). Brew and Mantai (2017) argue that how academics view UR and the relationship between teaching and research plays a role in faculty members' UR designs. Their interview study identified different perceptions, including some seeing UR as inferior, which can be counter-productive (Brew and Mantai 2017). Many faculty members find teaching UR challenging, and some choose to focus on techniques rather than a comprehensive approach, resulting in a

concern that students may not be able to appreciate the value of research in the discipline (Welch and Panelli 2003).

How faculty members' perceptions of the research-teaching nexus influence their approaches to UR remains inconclusive (Mägi and Berkens 2016). This is partially due to various levels of autonomy enjoyed by faculty members in different contexts. Brew (2013) suggests that curriculum decisions are often made at a departmental or institutional level, and faculty members' autonomy is often exercised within their courses. Therefore, it becomes important to situate relevant research in the curricular contexts. However, such studies are scarce as existing research tends to explore the research-teaching nexus or UR as mainly individual endeavours (e.g. Colbeck 1998). We follow Elton (2001) to argue that 'the real locus of the teaching-research link does not lie in teachers or even in learners, but in the curriculum process' (p.54). Meanwhile, the research-teaching nexus is challenged by the growing neo-liberalism that tends to separate teaching from research (Beerkens 2013).

This study investigated the UR approaches adopted by faculty members as a learning process in four curricula in two research-intensive universities in Hong Kong. Following a multiple-case study methodology, curricular documents were reviewed, and 18 faculty members were interviewed. The findings revealed an overall positive perception of UR. The research-teaching nexus, however, was perceived differently between different faculty members, with concerns over ethics and power relations.

Literature review

Undergraduate research

UR is defined as 'an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline' by the Council of Undergraduate Research (2006). This definition has been refined by Beckman and Hensel

(2009) to accommodate various UR practices positioned along eight dimensions: student-centred versus outcome-centred, student-initiated versus faculty-initiated, all students involved versus selected ones, curriculum-based versus co-curricular projects, collaborative versus individual, original to the discipline versus original to students, multi-disciplinary versus within a discipline, and finally, campus-oriented versus professional-oriented. We adopt this more inclusive definition in the present study.

UR has been regarded as a high-impact instructional practice (Kuh 2008). Seymour et al. (2004) found science students undertaking research gained confidence in being a scientist, clarification of career plans, and more active research attitudes. In social sciences, Cuthbert, Arunachalam, and Licina (2012) reported that students were highly motivated to conduct research. Authenticity constitutes a key feature of UR. Wald and Harland (2021) suggest that students undertaking authentic research will likely develop ‘powerful knowledge’, which allows its owners to apply it in new contexts and solve complex problems. Authenticity is conceptualised by Wald and Harland (2017) as consisting of a close relation to real-world scenarios, self-awareness as being a learner, and a sense of meaning associated with research.

Research-teaching nexus

UR in research-intensive universities needs to be situated in the concept of the research-teaching nexus, referred to as mutually beneficial relationships between research and teaching components of academic work (Neumann 1992). Early ideas of the research-teaching nexus can be traced to the Humboldtian model that defines university as a place where teaching and research are inseparable (Humboldt 1810, as cited in Robertson, 2007), but this tradition was challenged by Hattie and Marsh (1996) that finds only a slightly positive relation between teaching and research.

Faculty members maintain a positive view of the research-teaching nexus (Farcas, Bernardes, and Matos 2017). Still, there are different perceptions of how research and teaching should be connected. A study with senior academic administrators reveals three levels of the nexus: the tangible that translates disciplinary research to teaching materials, the intangible that infuses research attitudes into teaching practices, and the global that shapes teaching through departmental research activities (Neumann 1992). A study in information/management science shows that academics only see a unidirectional relationship—research informs teaching (Grant and Wakelin 2009), whereas other studies find reciprocal relations between teaching and research (e.g. Brennan et al. 2019; Coate, Barnett, and Williams 2003; Robertson and Bond 2001).

A curriculum perspective

Embedding UR in the curriculum potentially enhances the research-teaching nexus (Spronken-Smith and Walker 2010). Scholars (e.g. The Boyer Commission 1998; Fung 2017) argue for implementing UR across the curriculum, enabling learners to develop the criticality they will need in a ‘post-truth’ world (Hughes 2019, emphasis in original). Possible connections between research and teaching at a curricular level include content development (research-led), teaching of research processes (research-oriented), integration of inquiry-based learning (research-based), and systematically investigating the learning processes (research-informed) (Griffiths 2004).

The literature distinguishes between students exploring new knowledge and learning existing knowledge. According to Levy and Petrusis (2012), *authoring* and *producing* describe students developing new knowledge with self-formulated and teacher-designed topics, respectively. *Pursuing* and *identifying* deal with existing knowledge with the former involving students’ self-formulated questions. Zimbardi and Myatt (2014) identified five

approaches based on the forms of engagement: apprentice (students supervised by faculty members); industry project; inquiry project, research methods course, and a combination of the above types.

Spronken-Smith and Walker (2010) conceptualise students' progression from structured inquiry to open inquiry throughout the curriculum. Open inquiry is more likely to enhance the research-teaching nexus because it offers students opportunities to construct knowledge new to themselves and to faculty members, thereby generating new ideas to faculty members' own research (Spronken-Smith and Walker 2010).

Brew and Mantai (2017) differentiate holistic implementation of UR across the curriculum through coordinated efforts from atomistic approaches comprising fragmented tasks. They further distinguish between practices within courses and integration into a scholarly community. While both these two categories engage students in the whole research process, the latter emphasises students' researcher identity and community building (Brew and Mantai 2017).

There is no definite conclusion on disciplinary differences. Although Colbeck (1998) and Robertson (2007) suggest that faculty members more easily integrate teaching and research in disciplines where there is a low degree of consensus (e.g. humanities) than in disciplines with a higher degree of consensus (e.g. science), their findings have been challenged by studies showing strong research-teaching nexus in an ecology programme (e.g. Spronken-Smith and Walker 2010). Additionally, faculty members in professional fields focus on how research nurtures the development of professional knowledge (Lopes et al. 2014).

Research framework and design

This study aimed to explore faculty members' approaches to UR designs situated in the curriculum and in connection with the research-teaching nexus. The research questions were:

- 1) What are the approaches to UR adopted by faculty members on four undergraduate programmes in two research-intensive universities?
- 2) In what ways are faculty members' approaches to designing and facilitating UR affected by their perceptions of the research-teaching nexus and the curricular contexts?

A multiple-case study methodology was adopted, covering two science programmes, one interdisciplinary programme, and one professional-oriented programme. A multiple-case study (Merriam 1998) offers a rich understanding of several research sites and enables cross-case comparisons, leading to the identification of patterns that transcend individual cases. This methodology facilitated the examination of approaches to UR situated in the curriculum across disciplines.

Case selection

The four cases were purposefully selected based on two criteria: i) it needs to concern an undergraduate curriculum in a four-year bachelor's degree programme in a publicly funded research-intensive university with a teaching and research integration policy in place; and ii) the curriculum must contain multiple research opportunities.

The four programmes, each representing a case, were located in two research-intensive universities in Hong Kong: one comprehensive university (U-A) and one focusing on science and technology (U-B). Both universities were highly ranked internationally. A

high percentage of faculty members in both universities were research active. Among those on teaching-focused tracks, the vast majority possessed a research doctoral degree.

Promoting UR and research-teaching nexus was on both universities' agenda.

Regarding UR, U-A specified that 'all students experience a research-informed teaching and learning environment which promotes inquiry-based learning' (anonymised). U-B described its curriculum as 'forward-looking' and 'inquiry-driven' (anonymised). The emphasis on UR was also reflected in the graduate attributes such as critical intellectual inquiry (U-A) and the development of higher-order, transferrable competencies (U-B). For research-teaching nexus, U-A emphasised that most teaching staff were active researchers in the areas they teach and that faculty members should disseminate their research through seminars to both staff and students (anonymised). U-B framed teaching and research connections as beneficial to faculty members' development and encouraged them to involve undergraduates in their own research projects when possible (anonymised).

Data collection and analysis

Data collected included curricular documents and interviews. Specifically, the curriculum documents detailing the programme design and course information were analysed. Critical research components were identified initially by the first author and then confirmed by the programme director. Critical research components referred to courses, internships, capstones, and other elements that involved students in research towards developing research-related graduate attributes.

Twenty-four faculty members teaching critical research components were invited to attend a semi-structured one-on-one interview, and 18 accepted (see Table 1). The interviews focused on their role in the programme, approaches to UR, perceptions of UR and research-teaching nexus, and other factors influencing their course designs. Most interviews took from

40 to 45 minutes. All were transcribed verbatim. Ethical approval (SBRE-21-0297) was granted from the institution where the first author was based. Informed consent was obtained from all interviewees.

[Table 1 here]

The interviews were analysed using thematic analysis (Braun and Clarke 2022). First, we read the transcripts repeatedly to become familiar with the data. Second, we generated semantic codes to perceptions of UR (e.g. its purpose and components) and those of research-teaching nexus (e.g. how research and teaching were related), as well as UR approaches (e.g. format, support provided, and the role of students and faculty members). Third, initial themes were generated and compared across transcripts to determine whether the perceptions and approaches were unique or shared in different cases and whether there were any connections among perceptions, approaches and curricular influences. The fourth step was to develop and review the themes iteratively. Finally, the themes were consolidated.

Findings

An alternative profiling of approaches to UR

Five approaches to UR were discovered: project-based (in all cases); process-based (in all cases); lab-based (in Cases 1, 2); scenario-based (unique to Case 4); and research community-based (in Cases 2, 3 and 4). Each approach is discussed below.

Project-based: A project-based approach involved students undertaking a research project either individually or collaboratively. In most courses and all the capstones, students decided on their own research topic. For Case 3 (featuring an interdisciplinary programme), students needed to understand the perspectives of qualitative and quantitative approaches before

formulating their research goals. A project-based approach was believed to facilitate learning by doing, as illustrated in the quote below.

Research cannot be taught. We don't believe that we can just create a research course and teach students how to do research by telling. It has to be experienced. This is the philosophy underpinning our entire curriculum design. (Case 2, director)

Tackling a real-world problem, which should be either situated in the community or significant to the discipline, was emphasised as important.

We target the local wet market here in Hong Kong.... Students collected samples from the markets in high-income, average, and low-income communities and conducted assessments.... Finally, they need to generate a report in the format of a research paper. (Case 1, senior)

Process-based: A process-based approach focused on elements of the research process. For example,

It is important that students know how to assess papers. Their task is to dissect the papers and deliver critiques related to the knowledge that they have acquired during the semester. (Case 1, early-career)

The process-based approach in Case 3 was complex due to its interdisciplinary nature. In one course on research methodologies, three faculty members from different disciplines taught based on their own disciplinary views on research. These faculty members emphasised the

appreciation of fundamental debates about knowledge and inquiry. One explained his approach as follows.

I want the students to take a backseat to think about fundamental issues, appreciating different kinds of research from different perspectives. It is not about any specific methodology. If they want to learn a specific one, they can always learn it in future...

(Case 3, senior)

Lab-based: A lab-based approach focused on training technical research skills in laboratories with special equipment and tools. Students completed data collection, analysis, and report writing. Faculty members advocated for helping students understand how research was designed rather than simply how to conduct experiments. A senior faculty member in Case 1 elaborated that the laboratory design was revamped in 2019 toward stronger research-based learning. An excerpt below explains the revamped curriculum.

To ensure students are able to apply the knowledge and techniques after graduation, we got them to research how this technique can be used in scientific research.... So, they have to look for research papers that use the same technique. If there is any difference between what they did and what the papers stated, they need to explain why. (Case 1, director)

The lab-based approach in Case 2 had an additional feature. A significant laboratory experience was undertaken overseas, where students worked in a laboratory run by influential scientists in an area that matched students' interests. This experience was seen as a central curricular element in Case 2, as a highly relevant overseas research opportunity was viewed as critical to prepare students for their graduate school application.

Scenario-based: A scenario-based approach was unique to Case 4. It modelled the professional work cycles and translated them into a series of research courses. Students were provided with scenarios based on real projects in the field and required to identify the problem, collect data, analyse options, and present and defend solutions, as explained in the following excerpt.

We work with the industry to locate and use examples in the courses. We give students specific tasks every week, like guiding them with the task and helping them reach their destination. (Case 4, director)

All faculty members interviewed in Case 4 endorsed this approach. The coordinator overseeing the series of courses communicated with individual instructors to ensure that there was a coherent storyline across courses.

Research community-based: A research community-based approach prioritised the building of a research culture and a community of scholars in which students were exposed to authentic, collaborative research processes. Students learned how to work with others, mimicking the way a scientific community operated. For example,

Students need to taste the research culture.... They need to learn to work with lab mates on the research team.... They also need to get connected with their supervisors proactively.... This is the way a scientific community works. (Case 2, director)

A research community-based approach was sometimes implemented through launching a research group. For example, a research lab in Case 3 was established for this purpose.

Within the lab, students are working with different people.... It is also about exposure to different research fields.... It is valuable for students to see how different researchers make contributions to an interdisciplinary space. (Case 3, early-career)

The role of faculty members' perceptions

Faculty members were found to hold different perceptions of UR and research-teaching nexus. Overall, they had a positive view of the research-teaching nexus in terms of designing a curriculum that supports UR and inquiry. Most interviewees viewed a positive influence of research on teaching (e.g. using scientific findings in teaching contents), while only a few talked about how teaching influenced research; the latter focused on undergraduates bringing new research ideas to inspire faculty members. Differences were also noted between whether faculty members regarded the research-teaching nexus as existing at a departmental/curricular level or a personal level (see Table 3).

[Table 3 here]

Perceptions of UR can be categorised into a more holistic view and a focus on course-based implementation. The former highlighted the importance of developing students into lifelong learners with the ability to critically evaluate and apply knowledge across contexts; the latter viewed UR as an effective way of learning in a course.

Table 3 presents the nuances in adopting the UR approaches, which are mapped to faculty members' perceptions of research-teaching nexus and UR. Those who perceived a reciprocal relationship between research and teaching at both departmental and personal levels, and a holistic view of undergraduate research, actively engaged students as co-learners and co-researchers, enabling students to appreciate the connections between their learning and inquiry (Cell e, Table 3).

Research is integrated into all of the undergraduate study.... We see students as leaders and co-investigators. The research comes from our own kind of research areas. Students can see our enthusiasm for research, and we invite them into that enthusiasm. (Case 3, early-career)

With an attempt to induct students into a research community, these faculty members also designed UR in a way that represented very closely their own research experiences. Although such practices amplified most strongly in the research community-based approach, they were applied to all approaches. Below are two examples.

We give them interesting yet unusual research projects.... We send them to the street. ...That is ethnographic type of research. They can discover many interesting things.... I am also doing my ethnographic research, broadly in the same area, but on a different scale. (Case 4, early-career)

I encourage students to see my papers. [I] remember my first paper was completely broken down by my supervisor.... Some teachers may say that students don't have the knowledge or skills to write papers. Well, it is educators' responsibility to develop that knowledge and ability. (Case 1, early-career)

Though we do not intend to generate statistical patterns, we nevertheless observe that those who advocated for co-learning with students were all early-career faculty. The practice of using one's own research experiences to help students understand the process was shared. The phrase 'as I would do in my own research' was repeatedly identified in the interviews. However, several mentioned 'a very careful connection'.

I am drawing a strict line between students' research and mine to make sure that I don't use students to work for my research. We are researching in the same broad space, but I definitely will not take their work.... They inspire me but should not work on my research. (Case 4, early-career)

Some faculty members acknowledged that disciplinary research informed teaching contents, but not the potential for teaching to benefit research (Cell a, b, and c, Table 3). Typical reasons cited were that students would not be able to understand faculty members' research at the forefront of the discipline, and that UR cannot truly advance the knowledge of the field. This view was identified with a few faculty members in each case.

It needs to be clarified that not recognising the influence of teaching on research did not prevent these faculty members from coordinating UR. Moreover, those who viewed UR holistically tended to advocate developing research mindsets as a lifelong attribute (Cell c, Table 3).

When they get to senior positions, they need to make decisions.... They should use a research mindset and a critical lens. This can only be learned through step-by-step research processes involving literature review, analysis, etc. (Case 4, early-career)

Regardless of their perceptions of UR, faculty members who did not recognise research-teaching nexus at a personal level were unlikely to design research experiences that mimic their own research journey or involve students in their research projects (Cell a and d, Table 3). The quote below illustrates these views.

We introduce different research methods.... I don't think there's any obligation to plug in my research with the things that the students are doing. It's more like, well, if that made

sense, I would do it. But my research is in a niche area, and students should not be forced to learn about my research. (Case 3, senior)

Faculty members who recognised reciprocal relationships between teaching and research at a departmental level, and viewed UR holistically, showed a tendency to adopt open inquiries (Cell d, Table 3). Some also encouraged students to share their research findings at a departmental level. For example,

I ask students to solve new problems. It is very rewarding when they come up with another way of solving them.... They are also encouraged to present their research findings in seminars. This prepares them to go to graduate schools. (Case 2, senior)

Curricular factors

Curricular factors were mostly discussed in the interviews with programme directors and senior members. The curriculum in Cases 1 and 4 went through changes towards a stronger integration of research-based learning over the past three years, while that in Cases 2 and 3 was designed with a feature of research-based learning at the beginning. In the process of enhancing UR in Cases 1 and 4, the coherence of the programme was a critical consideration, as shown below.

We did careful checking on the sequence of the courses. That comes natural to us because it was the development process in our discipline. (Case 4, director)

The programme coherence was given priority over connecting research and teaching. For example, the Case 1 programme director suggested that connecting faculty members' own research and teaching might be too ideal.

It is about the cohesiveness of the learning process, not professors' research interests.

Students need foundational knowledge, which will not match any teacher's interest. We cannot afford to have all teachers teach what they are researching on. (Case 1, director)

For Cases 2 and 3, in which the curriculum was designed with research-based learning as a core element, a challenge was to recruit faculty members with an enabling mindset.

The first principle is to have devoted faculty members, and it is not a secret that not all faculty members are devoted. Fortunately, we have enough devoted ones. (Case 2, director)

A senior academic from Case 2 also commented on the importance of faculty members' commitment and emphasised the need for an open-minded approach to support research-based learning.

Regarding disciplinary differences, Cases 1 and 2 in the science discipline naturally included a lab-based approach. Case 3 featured an interdisciplinary programme, making a research community-based approach essential, because students needed guidance in navigating the interactions between arts and science. Case 4 with a professional orientation made a scenario-based approach particularly useful. That said, there were also shared approaches across cases.

Finally, how the course was positioned in the curriculum made an influence. In early years, faculty members focused on building knowledge and arousing interest. In later years, the focus changed to learning advanced techniques and tackling more complex problems. However, there were exceptions as the project-based approach comprising complex problem solving was also found in first-year courses.

Discussion

An alternative profiling of approaches to UR

This study identified five approaches to UR: project-based, process-based, lab-based, scenario-based, and research community-based approaches. While they could largely be mapped to the literature (e.g. Griffiths 2004; Levy and Petrulis 2012; Zimbardi and Myatt 2014), our profiling includes unique features (Table 2). Students' active participation in research was detected, and open inquiry was found in the first year. According to Spronken-Smith and Walker (2010), open inquiry is typically found in senior years, but its implementation in first year could be beneficial. Moreover, we did not find students passively learning existing knowledge based on faculty members' research (i.e. 'research-led' teaching, Griffiths 2004), which differs from studies showing that much UR does not give students an active role (e.g. Farcas, Bernardes, and Matos 2017).

[Table 2 here]

Specifically, the project-based approach is similar to research-based teaching (Griffiths 2004), 'authoring' (Levy and Petrulis 2012), and inquiry project (Zimbardi and Myatt 2014). The process-based approach shows more flexibility than the research methods courses (Zimbardi and Myatt 2014), because it could focus on one or several elements in the research process. The lab-based approach is not new in terms of its nature, but we included it to highlight the importance of experimental research at laboratories to science disciplines. The scenario-based approach is considered as a new contribution because it embraces both industry project (Zimbardi and Myatt 2014) and the 'throughline' concept of Fung (2017), supported by evidence in Case 4—a professional-oriented programme. Finally, the research community-based approach is another new addition. Existing typologies have not included

this approach explicitly, although implied in research-based learning (Griffiths 2004). Moreover, this approach in our study also contained structural elements (e.g. research groups or clubs), complementing the intangible nature of research communities in the literature (e.g. Wald and Harland 2017). It is also broader than apprenticeship (Zimbardi and Myatt 2014), as the former embraces dynamic interactions beyond faculty-student supervisory relationships.

The role of faculty members' perceptions

Faculty members' perceptions of research-teaching nexus and UR were found to have nuanced impacts on their approaches to UR mainly in terms of the pedagogical sides of these approaches. Those who recognised a reciprocal relationship between research and teaching at multiple levels, and viewed UR holistically, actively engaged students in a research community in their courses. They also assumed a significant role, as a role model, a co-learner, and a mentor, in the community. Some used oneself to illustrate the painstaking yet steady development as a researcher, while others brought students along with their own research journey. 'Use of self' is a concept in social work, denoting sharing of one's experiences with clients through thoughtful self-disclosure and bringing the self to the therapeutic relationship (Daley 2013). Though no interviewees referred to this concept, some applied it to facilitate students' integration into a research community. In the literature, integration into a research community is conducive to student learning but requires intricate designs (Brew and Mantai 2017). We suggest 'use of self' to be a possible solution, as it could be in the form of sharing one's own thinking or writing, and is considered less costly.

Meanwhile, concerns were raised over 'use of self'. Several interviewees tried not to use students as labourers or press them towards a direction that benefits themselves more than the students. Concerns about programme coherence were sometimes incompatible with 'use of self'. In the literature, the curriculum being distorted when faculty members focus too

much on incorporating their own research has been reported (Duff and Marriott 2017). Our findings showed faculty members' attempts to avoid these pitfalls. Nevertheless, further questions might be asked regarding whether the current practice is most effective since we might argue that students could have been offered more complete information to make informed decisions to participate in faculty members' research or not. After all, transparency about one's research might enable faculty members to illustrate abstract research processes such as idea generation and consolidation.

Faculty members' perceptions were important, but they did not seem to impact on the broader curricular aspects of the undergraduate research designs. For example, a coherent storyline cutting across multiple courses as part of the scenario-based approach does not just depend on individual perceptions. This finding aligns with Brew's (2013) observation that faculty members' decision on undergraduate research design concerns mainly the pedagogical aspect.

Disciplinary differences

Disciplinary differences were identified. The lab-based approach was unique to the science disciplines and the scenario-based approach unique to the professional-oriented programme. The interdisciplinary programme had additional complexities in its UR implementation. Interestingly, we did not discover differences between disciplines regarding faculty members' support for UR or the level of integration of research into the curriculum. These findings challenge previous studies implying that science faculty members tend to see teaching and research as separate (e.g. Colbeck 1998; Robertson 2007), while confirming Brew (2013) and Spronken-Smith and Wald (2010) that UR designs are not solely the decision by faculty members, but curricular requirements.

Study limitations

Several limitations need to be acknowledged. Not including all the faculty members coordinating critical research components might result in selection biases. Indeed, no interviewees opposed UR as an instructional practice. Although an overwhelmingly positive view on UR is also reported in the literature (Farcas, Bernardes, and Matos 2017; Grant and Wakelin 2009), we admit that the faculty members declining the interview might offer a different view. Another limitation concerns the possible difference between how interviewees described their approaches and their actual practices. To mitigate the negative impact of this limitation, we examined course descriptions (detailing learning outcomes, activities, and assessments) to obtain a more complete picture. Additionally, the identification of critical research components involved judgement, which might exclude courses that develop research mindsets and skills but do not explicitly focus on research. Finally, we only analysed the curricular contexts but did not fully take the university contexts, for example, different educational aims, into consideration. Future studies might benefit from a multilevel analysis.

Conclusions and implications

This study compiled an alternative profiling of approaches to UR and examined the role of faculty members' perceptions and the curricular contexts. Those who perceived the research-teaching nexus at multiple levels, as well as holistic UR, showed a tendency to share their own research experiences with students, induct them into a community of researchers, and bring them alongside their ongoing research. These practices respond to Barnett's (2000) argument for helping students deal with 'supercomplexity' through lecturers adopting 'teaching approaches that are likely to foster student experiences that mirror the lecturers' experiences as researchers' (p.163). Our findings, thus, contributed to the literature by

connecting faculty members' approaches, especially, the pedagogical aspects, with their perceptions of research-teaching nexus and UR.

Our findings have three main implications. First, coordinating UR does not require faculty members to have a perception of the research-teaching nexus at multiple levels as those without such a perception still followed the curricular requirements of UR. The implication to programme leaders is perhaps to focus more on curriculum design than individual perceptions, because the former helps ensure research opportunities are available to students. That said, having a perception of the research-teaching nexus at multiple levels shows benefits in enabling faculty members to foster student experiences that resemble their own research experiences, possibly leading to stronger authenticity (cf. Wald and Harland 2017). Second, the ethical and power relation concerns call for a more transparent process of curriculum design and communication with students, for example, explaining to students about their expected roles and rights in the research community (cf. Baxter-Magolda 1999). Finally, coordinated efforts among faculty members potentially enhance UR designs, because these efforts could help them better position their courses in the programme, contributing to more authentic research experiences and enhanced support for students' research skills development across the curriculum (cf. Fung 2017).

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Table 1. Data collection: Critical research components and interviewees in each case

Case	Critical research components ¹	Interviewees
1. Science (U-A)	Research-related courses (5)	4 (1 director, 1 senior, 2 early-career)
	Directed study (1)	1 (early-career)
	Capstone (1)	
2. Science (U-B)	Research seminar course (1) Literature review (1) Proposal writing (1) International research exchange (1) Capstone (1)	3 (1 director, 2 senior) ²
3. Interdisciplinary (U-A)	Research method courses (2)	2 (1 senior, 1 early-career)
	Research-related courses (1)	1 (senior)
	Research lab (1)	1 (early-career)
4. Professional (broadly classified as social sciences) (U-A)	Foundational courses (2)	1 (early-career, teaching both courses)
	Research method course (1)	1 (early-career)
	Research-related courses (5)	3 (1 director, 1 senior, 1 early-career)
	Capstone (1)	1 (early-career)

¹To protect confidentiality, the courses were re-phrased. The number in brackets indicates the number of components in that category.

²The interviewees were involved in coordinating multiple courses.

Table 2. Mapping our five approaches to those identified in the literature

Approach	How the approach is situated in the literature
<p><i>Project-based</i></p> <ul style="list-style-type: none"> • Purpose: making new discoveries • Design: students undertake research projects with open-ended, self-selected topics. 	<p>A project-based approach is similar to the following:</p> <ul style="list-style-type: none"> • Research-based teaching (Griffiths 2004) • ‘<i>Authoring</i>’ (Levy and Petrulis 2012) • Inquiry project (Zimbardi and Myatt 2014)
<p><i>Process-based</i></p> <ul style="list-style-type: none"> • Purpose: acquiring research mindsets and skills • Design: students focus on elements of the research process and complete tasks designed by faculty members. 	<p>A process-based approach is similar to the following:</p> <ul style="list-style-type: none"> • Research-based and research-oriented teaching (Griffiths 2004); • ‘<i>Authoring</i>’, ‘<i>Producing</i>’ and ‘<i>Identifying</i>’ (Levy and Petrulis 2012); • Methods course (Zimbardi & Myatt, 2014)
<p><i>Lab-based</i></p> <ul style="list-style-type: none"> • Purpose: learning specific skills • Design: students undertake laboratory/experimental research 	<p>A lab-based approach is similar to the following but highlights laboratory settings.</p> <ul style="list-style-type: none"> • Research-oriented teaching (Griffiths 2004); • ‘<i>Identifying</i>’ and ‘<i>Pursuing</i>’ (Levy and Petrulis 2012)
<p><i>Scenario-based</i></p> <ul style="list-style-type: none"> • Purpose: enhancing decision-making abilities and career development 	<p>A scenario-based approach combines the following approaches:</p> <ul style="list-style-type: none"> • A ‘throughline’ approach (Fung 2017)

<ul style="list-style-type: none"> • Design: students undertake research tasks across multiple courses modelling the professional work cycles 	<ul style="list-style-type: none"> • Industry project (Zimbardi and Myatt 2014)
<p><i>Research community-based</i></p> <ul style="list-style-type: none"> • Purpose: developing a researcher identity and belonging • Design: students are inducted into authentic, collaborative processes of conducting research. 	<p>A research community-based approach integrates the virtues of the following approaches:</p> <ul style="list-style-type: none"> • Inducting students to a research community (Brew 2010); • The existential authentic (Wald and Harland 2017); • Apprenticeship (Zimbardi and Myatt 2014)

Table 3. Nuances in faculty members’ undergraduate research approaches mapped to their perceptions of the research-teaching nexus and undergraduate research

		Perceptions of the research-teaching nexus (i.e. relationship between research and teaching)			
		Disciplinary research influencing teaching (contents) at a departmental level	Disciplinary research influencing teaching (contents) at departmental and personal levels	Reciprocal relationships at a departmental level	Reciprocal relationships at departmental and personal levels
Perceptions of undergraduate research (i.e. what is important in undergraduate research and how undergraduate is situated in the curriculum)	Course-based implementation	a. Tend to use scientific findings in course contents and follow curricular requirements.	b. Tend to introduce research in the discipline to students.	N/A	N/A
	Holistic with an emphasis on student researchers’ identity and lifelong development	N/A	c. Tend to introduce the research in the discipline to students. Emphasise the importance of research mindsets as a lifelong attribute.	d. Tend to adopt open-ended inquiries and encourage sharing of student research outcomes in departmental seminars.	e. Tend to adopt ‘use of self’ and engage students in one’s own research projects. Design UR in a way that represents one’s own experiences.

Note: N/A indicates no interviewee falls in this category.