JOURNAL OF CHEMICAL EDUCATION



pubs.acs.org/jchemeduc

Article

# Crossing the Divide: A Transitional Undergraduate Research Project in Medicinal Chemistry

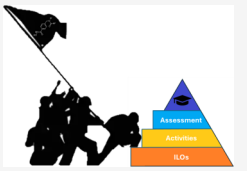
L. Palmer, A. Beekman, A. Ganesan, S. MacDonald, R. Hatley, and P. J. McDermott*

Cite This: J. Chem. Educ. 2025, 102, 4769–4775

Read Online



**ABSTRACT:** This qualitative case study describes the development, delivery, and review of an undergraduate research experience focused on developing research skills. We share some effective methods for delivering this type of course having designed a lab-based module that is supported by theoretical workshops to introduce students to research and help bridge the gap between undergraduate laboratory training and research. We have designed an assessment framework that focuses on assessing the process, rather than the product. Evaluation of this module with qualitative research methods has highlighted its effectiveness, and some areas for improvement, providing a framework for deployment in other programs looking to arrange undergraduate research experiences.




**KEYWORDS:** *Undergraduate, Laboratory Instruction, Organic Chemistry, Assessment, Learning Theories, Medicinal Chemistry, Applied Skills-Based Assessment*



## INTRODUCTION

### Teaching Research Skills in Higher Education STEM

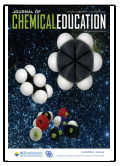
The development of research skills education in science, technology, engineering, and mathematics (STEM) academia has garnered much attention over the past 25 years. Driven by the demands of the workplace, largely industrial focused scientists, and the increase in students continuing in the academic work force, research skills in graduates is a highly desirable quality.[1]

The benefits for students are clear: Research, and the skills required to perform it, breeds analytical and critical thinking, problem solving, independence, and creativity. All highly desired professional skills. Until recently, research skills modules generally integrated undergraduates into research laboratories.[2] This "situated learning environment" (SLE) format allows a student to learn from more senior researchers through legitimate peripheral participation until they (hopefully) become full participants themselves.[3] This direct experience is highly desirable, but the benefits are only apparent if the ability to demonstrate the obtained skills is mastered.

The SLE approach is effective but requires the attention of other researchers in the lab for direction, supervision, and safety.[4] As such it is variable: the outcome of an individual project relies on the project itself, the supervision, the lab environment, and student performance - which in turn can be impacted by the student's prior experience. However, most undergraduate courses do not offer appropriate research skills training before the research project. This highlights a deficit in the research skills teaching in undergraduate courses. Are these undergraduate students moving into their first research project, ready to enter working research laboratories? Are they ready to experience a SLE? Without any research skills training, the likely answer for many students, is no.

Furthermore, the undergraduate research project assessment generally focuses on the product of the research. Most often this includes a dissertation element, written as a formal report or a journal article, and a conference presentation, perhaps a short talk or a poster.[5,6] These assessments closely mimic the way that researchers would share the results of their research efforts and so are perhaps the logical way to assess undergraduate research in an authentic workplace emulating fashion. This places the entire emphasis of undergraduate research learning on the production of valuable research data befitting of a "showcase" assessment output. Students are asked to produce work that looks like the research papers they have read, and if they continued into academic research, would be expected to produce. This could have the unintended effect of disenfranchising students from research because of their SLE experience. How can an undergraduate, a novice in their field, in an 8-to-24-week research project hope to generate enough novel research data? Their endeavors are put into stark comparison with the outputs of the postgraduate researchers in the lab who often have years of experience and have worked on a single project for an extended period. Students commonly report feeling that their research was not worthwhile because it did not generate the positive results they expected. Their experiments do not yield the desired results and maybe do not

Received: February 4, 2025
Revised: October 10, 2025
Accepted: October 14, 2025
Published: October 23, 2025







https://doi.org/10.1021/acs.jchemed.5c00162
J. Chem. Educ. 2025, 102, 4769–4775

satisfy their original hypothesis. They do not yet have the experience and insight to understand this is the norm (in research) and that the entire process is important. Instead, they are unable to achieve the image of their research project that was presented to them at the beginning, and as such feel that they are not capable of research.[7,8] This process misleads students and their understanding of research.[9] Assessing only the product, and not the process, is a poor way of assessing the student's research skills: the learning outcome that was identified as the reason for needing undergraduate research experience. This misalignment has been identified in the literature for some time.[10,11] A more appropriate assessment is required that measures the students' process in research. This would be a more authentic assessment for their research skills and would allow a student a better understanding of their own research aptitude and progression.

In our effort to address this misalignment, and the research skills training gap, we have developed an undergraduate research module in the third year of a four-year pharmacology and drug discovery integrated Masters program. The primary aim of the module is to aid the transition of Masters students from the more prescriptive learning culture of their first- and second-year laboratories, to the conventional research environment they will experience in their final year projects. This is a group research project focused on the development and testing of novel HDAC6 inhibitors as potential cancer chemotherapeutic agents. The design philosophy for this module was to create a program that integrates discipline specific skills, as well as work based, professional and life-long learning skills.[12] Key to the success of this endeavor was the constructive alignment of assessments to the stated intended learning outcomes.[13]

## TEACHING AND ASSESSMENT DESIGN

The central tenants of our strategy were to maximize active laboratory activities and to measure the process of development experienced by the student.[14,15] For a 20-credit module we provided 8 h of laboratory time per week. Assessments that focused on skills and attributes were selected and aligned to the laboratory sessions and weekly supporting workshops (Table 1). The chosen assessments were as follows: (a) an Observed Structured Practical Examination (OSPE); (b) a portfolio consisting of the students' data repository, lab book and a continuous reflective discussion; (c) a group presentation followed by a mock job interview. We also added a peer assessment adjustment to the group presentation mark. Examples of the mark schemes for these assessments, as well as the learning outcomes to which they were mapped can be found in the Supporting Information.

Students were expected to update the portfolio components on a weekly basis. Three submission points throughout the semester allowed us to check engagement. The observed practical was performed in week 12, with a formative assessment in week 10. Additionally, each lab session was implemented as a formative assessment of practical performance utilizing scaffolded questioning of the task in hand to build experience and familiarity with the assessment process. The presentation and interview are more challenging to assess continuously and so were supported in teaching sessions with formative group presentations and interviews in week 9 and assessed in week 12. Further authenticity was added to these assessments through the participation of external instructors from the RGD Science consultancy with extensive experience of recruiting and managing teams within the pharmaceutical industry. The contribution of the external instructors allowed us to provide a viewpoint of what the workplace wants and expects.

**Table 1. Module Timetable 2022 to 2023**

| Week | Monday, 1−5 pm | Tuesday 1−5 pm | Wednesday (Workshops), 9−11 am | Assessment |
|---|---|---|---|---|
| 1 | Induction Day − Target introduction, Docking Introduction and Lab expectations | | | |
| 2 | Lab | Lab | Docking Follow-up | |
| 3 | Lab | Lab | HDAC research history (a case study) | |
| 4 | Lab | Lab | Careers workshop with industrial collaborators | Formative Portfolio (written feedback) |
| 5 | Reading Week | | | |
| 6 | Lab | Lab | Analysis using data warrior | |
| 7 | | Lab | Docking/data analysis | |
| 8 | Lab | Lab | How to present | Summative Portfolio 1 |
| 9 | Lab | Lab | Group time | Formative OSPE (verbal feedback) |
| | | | | Formative Presentation and Interview (verbal feedback) |
| 10 | Lab | Lab | Group time | |
| 11 | Lab | Lab | Group time | Summative Portfolio 2 |
| 12 | Assessment Week | | | Summative OSPE |
| | | | | Summative Presentation and Interview |

The observed practical session (a four-hour observation on performing an experiment) evaluates how well the students had developed their practical skills, including what they had learned about the importance of safety, collegiality, and timekeeping in a shared workspace. The lab book and data file elements of the portfolio captured their improvement in data management and curation. The continuous reflective blog captured students' development in thinking processes and understanding of the project through their data analysis and discussion. The presentation (and peer evaluation), although intrinsically focused on results, was a group exercise designed to introduce the collaborative nature of research projects. The mock job interview added a unique element of authenticity because the students were interviewed for a real job that was a live advertisement on jobs.ac.uk. The interview focused on the job specification for the chosen vacancy but was based on the interview process used previously by members of the teaching team when they worked in the pharmaceutical industry. This element of the assessment also provided a mechanism by which we could align informal lab discussions and assessments because the students knew they would have to engage in such discussions in their technical interview.

## EVALUATION

### Participants and Recruitment

Participants were students enrolled on the Advanced Medicinal Chemistry module on the Masters in Pharmacology and Drug Discovery degree program(s) in 21/22 (cohort size = 7) and 22/23 (cohort size = 8). This module was scheduled in the first semester of the third year of a four-year Masters program. All students were invited to participate in the focus group conversations.



https://doi.org/10.1021/acs.jchemed.5c00162
J. Chem. Educ. 2025, 102, 4769−4775

### Focus Groups

Two focus groups were held, one with the 21/22 student cohort and one with the 22/23 cohort (Table 2). Across the two years, 12 of the 15 students attended. A Senior Research Associate external to the teaching team with experience in qualitative research methods facilitated the 60 min focus groups. The in-person discussion was audio-recorded and transcribed verbatim (using MS Teams). A semistructured topic guide was used to facilitate discussion (Supporting Information).

**Table 2. Focus Group Participants**

| ID Code | Cohort | Male/Female (M/F) |
|---|---|---|
| P1 | 2022 | M |
| P2 | 2022 | M |
| P3 | 2022 | M |
| P4 | 2022 | M |
| P5 | 2022 | M |
| P6 | 2022 | M |
| P7 | 2022 | M |
| P8 | 2023 | F |
| P9 | 2023 | F |
| P10 | 2023 | M |
| P11 | 2023 | M |
| P12 | 2023 | F |

### Data Analysis

The analytical process involved an iterative review of the data, guided by questions aimed at identifying coherent narratives and themes. Initial coding focused on the paragraph and statement level of the transcripts. Through the iterative process, open codes were grouped into a series of themes (Figure 1).[16] Credibility and consistency of the thematic analysis was ensured through collaborative coding of the focus group data. Three researchers independently reviewed the transcripts and audio recordings. A series of group meetings were held in which the researchers discussed the emerging themes to resolve discrepancies and to refine the coding framework. Disagreements were addressed through discussion in the group meetings until a consensus was reached and all researchers were confident that interpretations were aligned and there was a shared understanding of the data.

## RESULTS AND DISCUSSION

The key themes and subthemes along with example quotes from focus group participants are discussed individually below.

### Theme 1: Changing Perceptions

This theme focuses on how the student's expectations of themselves and the teaching team changed over the course of the project.

**Wanted More Support Initially.** Particularly at the start of the project, the students described feeling that it was too much of a jump from previous modes of learning and that they needed more support.

*P12: "just more kind of checking in... Even though we could ask for help, so that was fine. But I think it was just really independent, and I think, I was shocked".*

The requested support varied from staff telling them what to do in the lab, signposting to videos and guidance resources, increased unsolicited checking in from the staff, extra teaching sessions outside of lab time, and additional Q and A sessions. The students' suggestions for extra support all seemed to focus on a desire for more information and structure. This is understandable in the context of the significant change in the mode of learning they were experiencing.

**Wanted a Curated and Predictable Experience.** In addition to requests for more general support, feedback from the students indicated they would have felt more comfortable (at least at first) with a more predictable experience in the lab. A common theme in their comments was that it took the teaching team too long to tell them what the correct set of conditions were to use. Prior to this module, the students will have only completed lab practical sessions in which every reaction had been performed many times before. They will have known that if they follow the instructions, they should get the "correct" result. Breaking this perception was a key objective in this module. In addition to this, they wanted staff

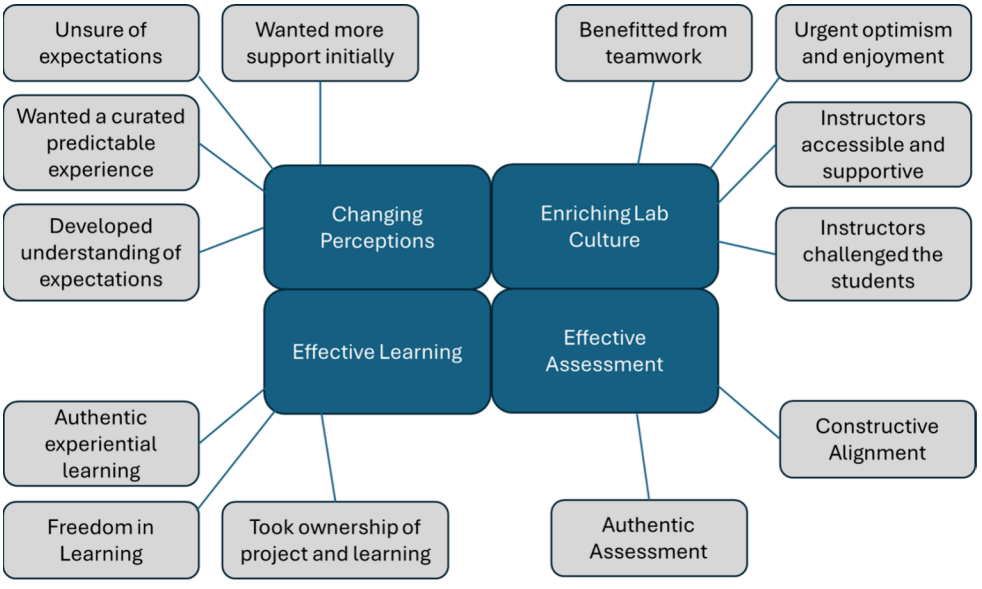



**Figure 1.** Theme map from focus group analysis. The overarching themes are shown in blue and the associated subthemes in gray.



https://doi.org/10.1021/acs.jchemed.5c00162
J. Chem. Educ. 2025, 102, 4769−4775

to provide comprehensive guidance that would account for every possible eventuality in the lab so that they were not surprised.

*P12 - "before going into the lab, just for example this acetone thing [sample contamination with acetone], maybe just a small note saying that it could happen. So, if it happens, you're doing it... you're experiencing it, but there's just a heads up in case it happens in case you're just shocked".*

**Unsure of Expectations.** Students were commonly unsure of expectations with regards to their own performance. They wanted to know if they were doing well and struggled to find a way of determining this at the start.

*P11 - "you wanted to kind of know,... "am I doing well"..., because usually you do workshops and things during semester, and you can know how well you do".*

They were also unsure of expectations of how to work collaboratively with their peers. Most notably, they were uncomfortable revealing they were struggling, or they did not know what to do.

*P1 - "We didn't know if we should cooperate between each other or just do it on our own and figure out. So, everyone was really confused in their belief and trying to keep to themselves [in the lab]."*

They were also uncertain of expectations of how the instructors were to guide them. Many commented that interventions from staff came late and they were allowed to fail too many times before staff intervened.

**Developed an Understanding of the Expectations.** The students described a realization that the expectations (or the measurement) of their performance were focused on the process rather than the results for this project.

*P11 - "I would say don't stress too much about making the final products and spend more time focusing on understanding what you're doing...put time into researching around what you're actually doing..."*

In line with this, they also acknowledged that the "jump" in expectations of their performance was necessary.

*P10 - "I think the jump was necessary because...you go from learning about the science to actually doing the science".*

This observation, in comparison to the theme describing their initial requirement for more support, speaks to a development in their ability to work independently and a greater appreciation of what is required to work in a research arena. They talked positively about the way instructors would prompt them to find answers to their questions rather than give the answers to them. Their ability to do this appears to have given them a greater sense of confidence in their own problem-solving skills. This dynamic has also led to a realization they had a lot more freedom in their work. It also seems to have given them a greater sense of ownership over the tasks. Interestingly, they described how this sense of ownership led to a reduced level of anxiety about the outcome of their work. Augmenting this greater feeling of freedom was the realization that everyone else had struggled and they were not expected to be perfect. They adopted a collegiate way of working very quickly.

*P10 - "these are the decisions you make in your own research and if you get it wrong you just have to start again that's science. You have to make mistakes... Mistakes happen... and a lot of the time you don't know why the mistake has happened but, actually being able to talk to people was really useful because... at least you come up with ideas as to why it happened."*

### Theme 2: Enriching Lab Culture

This theme focuses on how the lab setting positively affected the student's learning and development.

**Benefitted from Small Group and Teamwork.** Seemingly essential to the enriching interactions students had with staff and peers was the small class size. This allowed students greater access to staff time in which they could develop a working relationship. The students reported a greater sense of ease and confidence in working as part of a team as a result of working so closely with their peers. The nature of the work gave more space for discussion and collaboration, which they embraced.

**Urgent Optimism and Enjoyment in the Lab.** There were multiple direct mentions of the lab time being enjoyable. The strongest theme was students expressing frustration they did not get to complete the synthesis. They wanted to know if any of the compounds showed activity. This was linked to a desire to know if their modeling and subsequent molecular design had been effective. This ties in with the theme of taking ownership of the project. They were not making compounds that had been provided to them. They were working on compounds they had designed. They were "their compounds".

*P11 - "so there was a chance we would make the final product and then we could actually measure them on the assay. Because one cool thing that would have brought it together is if we could test if our docking was right"*

Students expressed a desire to do more lab work. Most notably, they wanted to come back outside of the module to carry out unassessed work to see if they could get the compounds to the testing stage. This ownership of the molecular design seemed to instill an intrinsic motivation for the research project that proved enduring.

*P11 - "I only decided to keep going at it because I was just trying to get better at docking. And then it just happened that I found a better set of results"*

**Instructors were Accessible and Supportive.** Students often stated they felt the culture and environment in the lab was conducive to their development. A key element of this was that students trusted the staff and found them approachable. They felt they were there to support their learning. It was a key benefit having a real research exercise that allowed staff to engage with the students in an authentic way.

*P6 - "And you could always go to a lecturer or one of the techs and say..., I don't really know what I'm doing, and they would be completely open and happy to talk to you. And it just always felt like the whole purpose of them being there was they just wanted you to take up as much as you could in preparation for your own career."*

**Instructors Challenged the Students.** The students responded positively to instructors handing back the responsibility for solving the problems they encountered. This observation also speaks to the trust that had been built up through interactions with teaching staff in the laboratory.



https://doi.org/10.1021/acs.jchemed.5c00162
J. Chem. Educ. 2025, 102, 4769−4775

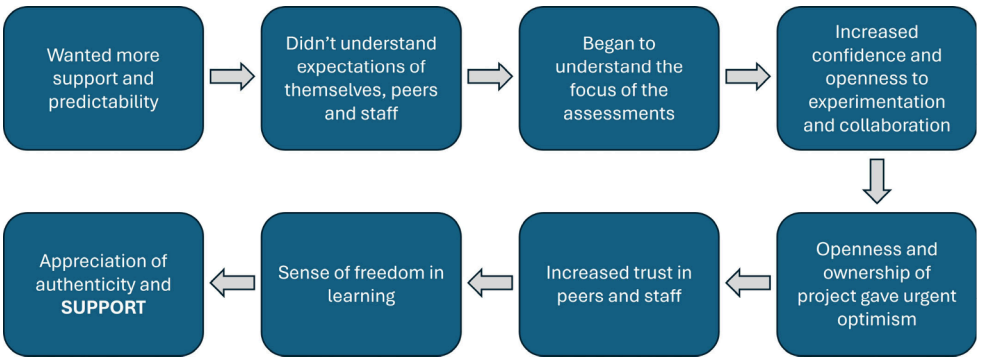



**Figure 2.** Timeline of development in learning behaviors and attitudes over the course of the module.

*P5 - "they won't give you the answer as such, which is great because it means you think about it... They just kind of prompt you to the right direction."*

### Theme 3: Effective Learning

This theme explores the perceived learning benefits of this new way of working.

**Authentic Experiential Learning.** Multiple elements of the practical work came out in this sub theme. Students liked the authenticity of the skills and techniques they were learning.

*P4 - "I feel we've learnt so much more from this. There is a practical element of what you're actually going to be doing in a workplace, rather than being sat there and having to do... exams."*

Students valued the autonomy they were given. They talked about how they learned by having the responsibility to solve problems themselves. This was often articulated as learning from their mistakes. Although many struggles were reported with the transition to a more independent and open way of working, the students ultimately came to feel they had benefitted from rising to the challenge.

*P10 -"I think it lets you come up with the actions to fix it yourself rather than being told "you've made a mistake. Don't do it this way. Do it that way"... It is like "you've made a mistake but how can you solve it"?"*

**Freedom in Learning.** It was striking to see how often students commented they felt free to make mistakes and that they learned from them. This was often linked to feeling comfortable discussing their mistakes or unexpected results with staff. They demonstrated a greater understanding of the nature of research through this interaction with the project.

*P1 - "we could compare these new forms of assessments to traditional... exams. Exams is just you memorize facts as I'm just right... I mean..., but here you can learn some facts. And so, we basically use it in real life experience. So basically, you also improve your creativity".*

**Took Ownership of Project and Learning.** Students described making their own decisions against a backdrop of (seemingly) confusing or nonlinear advice. Most pleasingly they described feeling a greater sense of ease with the prospect of failure because they owned the decisions they made. They felt that rising to this challenge was a key part of their learning.

*P9 - "It really helped you develop your problem solving like critical thinking. Because you have to go "okay, I've been told this and this now what am I gonna do"... "how am I gonna try and solve this problem with my knowledge, my experiences and what they've told me". And then... decide what to do and if you went wrong, you'd be like "that was my, that was my decision"".*

### Theme 4: Effective Assessment

This theme focuses on the way assessments affected learning behaviors and attitudes.

**Constructive Alignment.** Comments from the students showed they felt they learned much more from the combination of research activities and assessments. They appreciated the way teaching and research activities prepared them for the various assessments undertaken.

*P11 - "I feel like the lab sessions were successful. Because by the time we come round to the OSPE [observed practical assessment] ... I felt so much more confident in the lab because it was basically a fresh start. We did... the practical, "right up to speed, here we go". And I felt like everything I'd learnt over all the weeks, was in my head now and I did way better in the OSPE than I'd ever done at anything in the lab before, so I really did feel like it actually helped".*

**Authentic Assessment.** Students valued the activities because of their direct relevance to their intended career paths.

*P12 - "It's quite different as well. So, I think the skills you gain from it can be taken... and used for later life, like the interview practice, the presentation. You never had something like that before. And so, I think it's really useful".*

The continuous nature of many assessment elements, as well as a lack of focus on results, appeared to have a disinhibiting effect on the students. This allowed them to shift their focus away from grades and onto their own learning.

*P10 - "We didn't get there; we get that and that wasn't important. It was the skills we learned and the processes we learned".*

*P10 - "The sense of achievement, in the end, didn't come from finishing because I didn't finish. But it came from the amount of learning".*

## CONCLUSION

A primary aim of this module was to revisit the relationship between staff and undergraduate students and generate an effective and supportive academic community.[17] We became aware that the potential for success in this approach would be constrained by the student's prior conceptions of research as highlighted by Wilson et al.[8] It was Wilson who also suggested a strategy of reconceptualizing these early research experiences as "work-based learning". In doing so we were advised to draw on the widespread use of reflective practice in work-based environments to give a more effective focus on process related learning. These concepts presented by Brew and Wilson certainly resonated with our experience of delivering this module. At the start, students felt unsettled and in need of more support as they reconceptualized what is was to work on



https://doi.org/10.1021/acs.jchemed.5c00162
J. Chem. Educ. 2025, 102, 4769−4775

a live research task. We planned for this in designing learning outcomes, synchronous teaching and assessments that were always framed as being authentic to work-based environments. Reflective practice was introduced via the continuous discussion and blog. The in-term monitoring of lab books, data repositories and lab behaviors (assessed in the OSPE) served to push the focus of the assessment onto the process rather than the final product. Authenticity was augmented by the contributions of our industry collaborators as well as tangible career centric assessment tasks in the form of the presentation and the technical job interview.

Initial fears and anxieties appear to have been allayed as students grasped a better understanding of how they were to be assessed and how that related to their day-to-day lab practices (Figure 2). Pleasingly, students articulated their response to this realization as an increase in confidence and a greater sense of openness to collaborate with peers and to experiment in their work. This greater level of openness and a sense of ownership over the project (they were making molecules they had designed themselves) led to an urgent optimizm that endured throughout the module.

The collegiate nature of the working parameters and the accessible and supportive teaching approach helped to build trust between staff and students. This in turn gave students a greater sense of freedom in their learning, which was palpable to the observing teaching staff. Finally, students gave positive feedback about the authenticity of the assessments as well as the effectiveness of their implementation. They spoke about the relevance of assessment activities to their future careers. They also felt that in-semester practices prepared them well and that they were well supported.

Student satisfaction with the module and attainment in the assessments were shown to be very high via the usual quantitative measures (Supporting Information). But we have focused unashamedly on qualitative methods in our evaluation. We have done this in the belief that measures of development in the student's confidence and learning behaviors in the context of research work, as well as their perception of what good research practice involves, are the best measures of progress in training students to enter a SLE. We believe it is better to provide a structured variation on the research project experience they will face the following year, so they undergo (at least partially) the metamorphosis from an undergraduate student to a full participant in research.

Recent publications in the development of undergraduate research exercises highlight the growing interest in this type of work. A recent scoping study of assessment of student learning in UG research in Australian and New Zealand universities,[18] indicated that traditional and summative assessment that is focused predominantly on research outputs, can be inadequate to assess the learning and development of UG research participants. This paper goes on to say that exemplar programmes, recommended to their study, exhibited greater focus on learning in the research process. Similar findings were made in preceding research.[1,19,20] Citations of this work already link process focused assessment practices with improved development of desirable learning traits such as epistemic agency and socio-emotional skills.[21] Having said this, assessment of undergraduate research still relies overwhelmingly on "showcase material" (posters, presentations, papers etc) which present final outcomes. These types of assessment risk disenfranchising students from research if they are unable to emulate the image of the research project that was presented to them. Undergraduate research assessments are almost ubiquitous across higher education institutions. We believe improvements in assessment practices around undergraduate research has the potential to make a rapid and far-reaching impact on the quality of learning and development in the context of an activity most valued by academics and employers alike.

### Limitations of the Methods

Case studies can also oversimplify or exaggerate the subject being examined. Guba and Lincoln report that case studies can "masquerade as a whole when in fact they are but a part".[22] As such they are heavily influenced by the bias of the researcher and the reader. The ability to keep a focus group on topic without imprinting their own biases takes training. We recruited a skilled researcher with extensive experience in focus group work to help avoid this bias. Focus groups also may not allow all views to be expressed. In the end it is the views of the group that are expressed, rather than the individual. An experienced moderator can limit this bias but not eliminate it. There is also a risk of the Hawthorne effect and selection bias. Participants my express the views they think the observer wants to see.

### Ethics Review and Informed Consent Statement

Ethical approval for this study was obtained from the UEA School of Education and Lifelong Learning Research Ethics Subcommittee (Approval No. ETH2223-1126, Date:6th March 2023). Written informed consent was obtained from all participants prior to their inclusion in the study. Participants were provided with detailed written information about the study's purpose, procedures, risks, and benefits. All data were anonymized and stored securely to ensure participants' confidentiality. The authors declare no conflicts of interest. This research was not supported by any external funding agency.

### Financial Conflicts Statement

The authors declare that there are no financial conflicts of interest or potential sources of bias related to this manuscript, except for the following: Two of the authors, Simon MacDonald and Richard Hatley, are directors of RGD Science Ltd., an education consultancy. This consultancy may benefit from the findings of this study. These two authors were tasked with designing and delivering teaching sessions but did not participate in the evaluation of the outcomes. No other funding was received for this study, and there are no additional affiliations, financial or management relationships that could influence the results or interpretation of the findings.

## ■ ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.5c00162.

Full description of the design of the research task undertaken by the students (including relevant risk safety statements), the slide deck for the module introduction, the slide deck for the assessment introduction, an indicative timetable for the module, the mark schemes for each assessment type, module feedback results, details of student performance, the topic guide for the evaluative focus groups, code framework from the thematic analysis, and a discussion



https://doi.org/10.1021/acs.jchemed.5c00162
J. Chem. Educ. 2025, 102, 4769−4775

of a series of selected student specific focus group responses for each identified theme (PDF)

## AUTHOR INFORMATION


### Corresponding Author

**P. J. McDermott** − *School of Chemistry, Pharmacy and Pharmacology, University of East Anglia, Norwich, Norfolk NR4 7TJ, United Kingdom;* orcid.org/0009-0000-8122-4222; Email: p.mcdermott@uea.ac.uk

### Authors

**L. Palmer** − *School of Chemistry, Pharmacy and Pharmacology, University of East Anglia, Norwich, Norfolk NR4 7TJ, United Kingdom;* orcid.org/0000-0001-7894-0674

**A. Beekman** − *School of Chemistry, Pharmacy and Pharmacology, University of East Anglia, Norwich, Norfolk NR4 7TJ, United Kingdom;* orcid.org/0000-0002-3056-6406

**A. Ganesan** − *School of Chemistry, Pharmacy and Pharmacology, University of East Anglia, Norwich, Norfolk NR4 7TJ, United Kingdom;* orcid.org/0000-0003-4862-7999

**S. MacDonald** − *RGDscience Ltd, Hitchin, Hertfordshire SG4 9S, U.K.;* orcid.org/0000-0002-4859-8246

**R. Hatley** − *RGDscience Ltd, Hitchin, Hertfordshire SG4 9S, U.K.;* orcid.org/0000-0002-3172-2511

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.jchemed.5c00162


### Notes

The authors declare no competing financial interest.

## ACKNOWLEDGMENTS

We are grateful for the support and patience of M. Bennett and his teaching laboratory technicians team in the synthetic laboratories, NewSci, UEA. We acknowledge and appreciate the expert facilitation of the focus groups by Thando Katangwe-Chigamba.

## REFERENCES


(1) Wilson, A.; Howitt, S.; Higgins, D. A Fundamental Misalignment: Intended Learning and Assessment Practices in Undergraduate Science Research Projects. *Assess Eval High Educ* **2016**, *41* (6), 869−884.

(2) Wilson, A.; Howitt, S.; Higgins, D. Assessing the Unassessable: Making Learning Visible in Undergraduates' Experiences of Scientific Research. *Assess Eval High Educ* **2016**, *41* (6), 901−916.

(3) Lave, J.; Wenger, E. *Situated Learning: Legitimate Peripheral Participation*; Cambridge University Press: 1991. DOI: 10.1017/CBO9780511815355.

(4) D'Angelo, J. G. Project Time! A Course-Based Undergraduate Research Experience, a CURE for the Traditional Organic Lab. *J. Chem. Educ.* **2023**, *100* (8), 2904−2916.

(5) Jenkins, A.; Healey, M.; Zetter, R. *Linking Teaching and Research in Disciplines and Departments*; HE Academy: 2007.

(6) Jenkins, A.; Healey, M. *Institutional Strategies to Link Teaching and Research: Full Report*; HE Academy: 2005.

(7) Wilson, A.; Howitt, S.; Wilson, K.; Roberts, P. Academics' Perceptions of the Purpose of Undergraduate Research Experiences in a Research-Intensive Degree. *Studies in Higher Education* **2012**, *37* (5), 513−526.

(8) Wilson, A.; Howitt, S.; Roberts, P.; Åkerlind, G.; Wilson, K. Connecting Expectations and Experiences of Students in a Research-Immersive Degree. *Studies in Higher Education* **2013**, *38* (10), 1562−1576.

(9) Howitt, S. M.; Wilson, A. N. Revisiting "Is the Scientific Paper a Fraud?". *EMBO Rep* **2014**, *15* (5), 481−484.

(10) Boud, D. Assessment and the Promotion of Academic Values. *Studies in Higher Education* **1990**, *15* (1), 101−111.

(11) Medawar, P. Is the Scientific Paper a Fraud? *Listener* **1963**, *70*, 377−378.

(12) Ruge, G.; Tokede, O.; Tivendale, L. Implementing Constructive Alignment in Higher Education − Cross-Institutional Perspectives from Australia. *Higher Education Research & Development* **2019**, *38* (4), 833−848.

(13) Biggs, J. Enhancing Teaching through Constructive Alignment. *Higher Educ.* **1996**, *32* (3), 347−364.

(14) Turner, N.; Wuetherick, B.; Healey, M. International Perspectives on Student Awareness, Experiences and Perceptions of Research: Implications for Academic Developers in Implementing Research-based Teaching and Learning. *International Journal for Academic Development* **2008**, *13* (3), 199−211.

(15) Howitt, S.; Wilson, A.; Wilson, K.; Roberts, P. 'Please Remember We Are Not All Brilliant': Undergraduates' Experiences of an Elite, Research-intensive Degree at a Research-intensive University. *Higher Education Research & Development* **2010**, *29* (4), 405−420.

(16) Braun, V.; Clarke, V. Using Thematic Analysis in Psychology. *Qual Res. Psychol* **2006**, *3* (2), 77−101.

(17) Brew, A. Teaching and Research: New Relationships and Their Implications for Inquiry-Based Teaching and Learning in Higher Education. *Higher Education Research & Development* **2003**, *22* (1), 3−18.

(18) Mantai, L.; Swain, C.; Bearman, M.; Brew, A. Assessment of Student Learning in Undergraduate Research Engagement. *Higher Education Research & Development* **2024**, *43* (4), 937−951.

(19) Brew, A.; Mantai, L. Academics' Perceptions of the Challenges and Barriers to Implementing Research-Based Experiences for Undergraduates. *Teaching in Higher Education* **2017**, *22* (5), 551−568.

(20) Lopatto, D.; Tobias, S. *Science in Solution: The Impact of Undergraduate Research on Student Learning*; Council on Undergraduate Research, Research Corporation for Science Advancement: 2010.

(21) Nieminen, J. H.; Ketonen, L. Epistemic Agency: A Link between Assessment, Knowledge and Society. *Higher Educ.* **2024**, *88* (2), 777−794.

(22) Guba, E. G.; Lincoln, Y. S. *Effective Evaluation*; Jossey-Bass Publishers: 1981.