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RESEARCH ARTICLE:

Embedding Undergraduate Research through Industry-Based Projects: Student Experiences

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Abstract

Traditionally, formal training in research methodology begins in postgraduate programmes; however, potential exists to embed high-impact research skills during the undergraduate programme to develop learning by inquiry, promote critical thinking and engaged scholarship. Identifying factors that affect students' research engagement can provide important practical implications to effectively encourage and facilitate undergraduate research opportunities. This exploratory qualitative study investigates the undergraduate student experience of the research process embedded in collaborative industry-based projects, through focus-group discussions. Using predefined domains from the interview guide, key themes emerging from the focus group discussions included a process-orientated approach to research, knowledge synthesis through data collection and handling, data collection experience, and students' experience of a collaborative and deep approach to learning. Key enablers of the research engagement included funding for undergraduate research and transfer of research skills into higher levels of study whilst key barriers were limited foundational research knowledge and the impact of emergency situations. Other emergent themes included knowledge transfer through early initiation of research in the undergraduate programme. Institutional and programmatic engagement is required to support undergraduate students with the rigours of becoming knowledge co-constructors for their graduate destination or continuation of postgraduate studies.

Keywords: *undergraduate research; industry-based projects; student experience; knowledge transfer*

Introduction

Undergraduate research provides an opportunity to nurture links between teaching and research by developing students' understanding and appreciation of research, thus breaking the long-standing divide between teaching and research (Walkington, 2015: 6). According to Walkington (2015: 6), "students as researchers", is student-engaged pedagogy, which emphasises the process of undergraduate research and inquiry. Research in this style may include measures to strengthen research-teaching linkages by developing and integrating students' understanding of research within a discipline. It can also use teaching and learning methods that simulate research processes, thus giving students a first-hand experience of research, for example, through inclusion of industry-based projects, which brings community engagement and research data from several sources into the curriculum for students to manipulate (Anderson and Priest, 2014). South Africa has 26 public Higher Education Institutions (HEIs) of which six are Universities of Technology (UoTs) (USAF, 2022; Matiki ,2014: 2126). UoTs in South Africa were formerly known as Technikons (Mtshali and Sooryamoorthy, 2019: 195) operating similarly to polytechnics in the United Kingdom (Vahed and Cruickshank, 2018: 566). The Durban University of Technology (DUT) is a HEI established in terms of the Higher Education Act 101 of 1997 (DUT, 2008: 2-3). DUT has a rich history spanning one hundred years as an institution in both the

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vocational and higher education sector. DUT is the result of a merger, which took effect on 1 April 2002 between the former ML Sultan and Natal Technikons. During 2005, DUT changed its name from "Durban Institute of Technology" to "Durban University of Technology" (DUT, 2008: 2-3). With this change came a concerted effort to increase its research profile (Vahed and Cruickshank, 2018: 567).

After the merger, DUT initially reflected a strong programme offering of diplomas and BTech degrees with some master's and Doctorates in Technology qualifications. Currently, there has been a noticeable shift from diplomas towards degree offerings, with all departments within faculties offering progression to postgraduate studies. In addition, there has been a stronger shift towards research, qualifications, and publications for both staff and students. Aligned to the DUT's ENVISION2030 strategy map, undergraduate research could be seen as one way of enabling innovative curricula and research leading to an engaged university with adaptive graduates to the job market (DUT, 2019). Supporting Undergraduate Research Excellence (SURE), a new focus of the Research, Innovation and Engagement (RIE) unit, began at the DUT in 2020, with the aim of enhancing scholarly excellence in undergraduate research and teaching, and linking discipline-based research with teaching to benefit student learning (DUT 2020). The research hub created through SURE is intended to drive research efforts from the undergraduate level and like Matikis (2014:2128) recommended, speaks to UoT's research having an entrepreneurial, community and academic focus since these research areas resonate with ENVISION2030. However, this approach is different to other traditional universities in South Africa, where the undergraduate research presence is traditionally more prominent and academically focused.

The benefits of undergraduate research have been well established. The use of research methodology and the hypothesis-driven scientific process helps students develop independent critical thinking skills which have the potential to translate beyond the classroom (Petrella and Jung, 2008: 92). A robust undergraduate research experience, as reported by Lopatto (2007: 298), includes multiple benefits such as developing a sense of tolerance for obstacles, learning to work independently and collaboratively, understanding how knowledge is constructed, developing self-confidence, and understanding that assertions require supporting evidence. Using Bloom's taxonomy (which is organised into six hierarchical categories of thinking skills and was later revised into action-orientated verbs with a less hierarchical structure), allows students to develop the ability to evaluate information critically, apply it, and create new knowledge with what they have mastered (Krathwohl, 2002: 216). The 21st-century graduate requires a mastery of higher-order thinking skills, making the shift from transmission-based to transformative-based pedagogical orientation even more urgent (Tarling and Ng'ambi, 2016: 560). Student projects in the Food and Food Science 301 and Food and Food Science 401 modules are designed to enable students to source, analyse and evaluate research data to create and underpin ideas and concepts, with tasks placing emphasis on higher-level thinking skills (Krathwohl, 2002: 215).

Two modules at the Department of Food and Nutrition: Food and Food Science 301 and Food and Food Science 401 participated in the SURE initiative through collaborative, industry-based projects with KERRY FOODS and the SPAR GROUP LTD, respectively. The aim of the collaboration was to enrich student experience, develop research skills and align curricula that are relevant to industry. In these modules, designed to transform students from "inquiry for learning" to "inquiry for knowledge building" (Levy and Petrulis, 2012: 97), students were provided with an industry brief to develop recipes according to pre-set criteria using the sponsoring company's ingredients. The task involved conducting consumer market research, analysing the findings, and pairing this with food industry trends to develop recipes. This process aimed to engage students in research and inquiry to improve their preparedness for industry and postgraduate research. However, success in embedding undergraduate research into the curriculum should consider the students' voice on their experiences to allow for review and reform of this pedagogical orientation.

In this study, the student experience is examined qualitatively through focus-group discussions (FGDs) after participation in collaborative, industry-based projects.

Undergraduate research at the Department of Food and Nutrition is embedded in some modules, but these are not consolidated, thus resulting in a fragmented structure. Research methodology as a module is offered in postgraduate studies for the first time, which is too late. Significant benefits are associated with early engagement in research, especially for first-generation university students (Ishiyama, 2002: 380) and it directly impacts student throughput rate (Ishiyama, 2002: 381; Shanahan *et al.,* 2015: 360). Additionally, almost half the student cohort often exit at the undergraduate programme level, meaning that they almost entirely bypass the teaching and learning gains associated with Walkington's "students as researchers" pedagogy (Walkington, 2015: 5). This, in turn, could impact the way these students think, behave, and engage with work-based inquiry and problem-solving once they join the job market. Embedding research processes more explicitly in the undergraduate programme can help to shift students from a rote-based, surface approach of 'learning to the test' and instead, shift students towards deep learning, which empowers students to develop an active approach to learning and to foster independent critical thinking skills (Shanahan *et al.,* 2015: 359). Thus, understanding how students experience the research process can help the faculty to determine how to package the research component to best nurture these skills at undergraduate level. Like Shanahan *et al.* (2015: 370), implications and measures associated with a more robust inclusion of research methodology at undergraduate level with a larger student cohort, would also need to be addressed. Once these are identified it may well require additional staffing capacity and scaffolding to build and develop student ability to ensure quality research.

Methodology

In this study, the qualitative research method was used, underpinned by phenomenography in the form of FGDs to assess student experiences for the purpose of gaining an emic perspective, allowing direct communication from participants without confining responses. Food and Food Science 301 and Food and Food Science 401 had 72 and 22 registered students, respectively, who were invited to participate in this study. The FGD participants were made up of volunteers and were not preselected to represent the student academic ability. Gatekeeper permission to engage in this study at DUT was obtained from the Directorate of Postgraduate Studies at DUT. At the end of both modules, Food and Food Science 401 and Food and Food Science 301, students were invited to participate in FGDs through class WhatsApp groups. Students who were interested in participating in this research were invited to a Microsoft Team meeting where a letter of information and details of the study were shared. Interested participants completed and returned the consent form to the researchers electronically. Participants were provided with a choice of dates and times to attend a FGD programme. FGDs comprising 6–8 members per FGD continued until meaning saturation in core codes was reached. This is when issues are fully understood and no further dimensions, nuances or insights into issues can be found (Hennink, *et al*. 2017: 593).

A semi-structured focus-group guide was developed with input from the research team and piloted among five second-year students to test the structure of the guide and the question design to determine an understanding of the questions and to establish whether it promoted discussion. Seven main domains were explored using open-ended questions: understanding of the research and the steps in the research, engagement in research in the undergraduate programme, experience of the research process through industry-based collaborative projects, key enablers of the research engagement, key barriers to the research engagement, importance of embedding research in the undergraduate programme and suggestions on how research could be embedded in the undergraduate programme. The FGDs were conducted in the online mode through Microsoft Teams. At the commencement of the FGD, permission to record the meeting was obtained. Each session

began with an introduction that included a brief explanation of the study, the FGD protocol and ethical considerations. Both researchers exchanged roles as moderator and co-moderator for each FGD. A note-taker transcribed the discussion and alerted the moderator to any chats on the platform. Each FGD took approximately 50 minutes to complete.

Audio recordings from each FGD were transcribed verbatim by two trained research assistants. To ensure quality control, both researchers reviewed the transcripts independently against the audio recording for potential discrepancies or incomplete data. Data analysis was conducted using Braun and Clark's (2006:77) framework for thematic analysis. The researchers familiarised themselves with the data by reading the FGD transcripts several times to obtain an overall understanding of the content, and the generating of initial codes and themes. Themes were then reviewed, defined, and named for interpretation. The researchers created a word table based on the pre-defined domains and inductively coded the transcripts to find the frequent, dominant, or significant themes within domains, first independently and then jointly, until consensus was reached. Procedures for rigour and validity in the form of validity checks were completed after each FGD and during thematic analysis by the researchers. This study used non-invasive methods and followed the normal protocol for approval by the DUT Institutional Research Ethics Committee (IREC). Participation in the FGDs was entirely voluntary. FGD recordings and transcripts were saved on a password-protected USB. To maintain anonymity, participants signed a non-disclosure agreement, and all questionnaires and transcripts were de-identified. Data sharing was only allowed between the researchers using a secure online workspace.

Findings and Discussion

Two FGDs were conducted, stratified by module and programme level. A total of 13 participants participated, with 7 participants in FGD 1 and 6 participants in FGD 2; there were 38% male and 62% female participants in total. Using pre-defined domains, emergent themes with corresponding representative quotations are presented in a supplementary file Table 1. For the domain "understanding of research and steps in the research process", two themes emerged: a process approach to research and knowledge synthesis through data collection and handling. The students indicated that research starts with an enquiry and uses systematic methods in a process-orientated approach to understand one's topic, determine the outcomes, and gain ethical clearance before beginning the data collection process, including designing and piloting surveys, as well as collecting data from different sources to problem solve within a set time frame. It includes recommendations and implementation measures to problem solve:

> "You must first know what you want to research about, and what are the outcomes."
>
> "An important step is to analyse the topic in-depth to get a better understanding."
>
> "Finding the methodology and a systematic approach to a specific outcome."
>
> "I would start with a hypothesis and then thereafter determine how I would arrive at my outcome."
>
> "First, you need approval from the Research Ethics Committee to conduct the study and consult with staff supervising your research. Then after approval of your study, you recruit participants and gather data."
>
> "Basic fieldwork – going out and physically collecting data from participants via surveys or questionnaires and piloting these."

> "Research has to be conducted within a set time frame."
>
> "We sourced articles and summarised the articles to gain understanding."
>
> "We analysed the data from the questionnaires to create new recipes."
>
> "An important step in the research process is to ask yourself questions like, is this relevant?"

Here and elsewhere in this study, explanations from undergraduate students provided a varied and insightful account of their perceptions of what research is; however, while it houses many elements of the research process, Holmes and Ainsworth (1997: 33) caution that there is a "messy reality" to research which looks nothing like the neat, finished articles students may be researching. The reality of this, they warn, can be demoralising for student writing, especially in the context of undertaking undergraduate research (Holmes and Ainsworth, 1997: 34). To this effect, through the scope of work framed within the SURE intention, the industry-based project for both third year and fourth-year undergraduate students provided ample collaborative opportunity for the students to understand, experience and actively engage in elements of the research process with guidance from their lecturers. Formative assessment practices, including the effective inclusion of a drafting-responding process, were used by the lecturers to support and develop student writing (Quinn, 1999). These collaborative practices are meaningful, as they create opportunities for "shared responsibility as well as shared power" (Shanahan *et al.,* 2015: 367).

Student responses acknowledged a need to mine data that is credible, reliable, and verifiable, and intended to underpin and reinforce a focus area or what one is trying to establish.

> "Research is when you gather information about a particular topic that you are supposed to study or … it's when you … find more information to back up what you already know or what you are trying to find out."
>
> "Research is finding information from a verified, reliable, and also reputable source of data."

Student awareness that the research and data gathering process is more complex and systematic is important, as it forms the bedrock for current and future research, especially when the student account of their research experience indicates that for them, the research process has irrevocably been altered to a rich learning experience, one that they would like to have repeated, even from the first year, so that they could gradually build towards a solid, research-immersed postgraduate level. Given that our students come from diverse backgrounds, with at times limited opportunities and resources to engage in research, it resonates with the strong global call to purposively include research at the undergraduate level (Shanahan *et al.,* 2015: 359). However, heeding this call has an impact on teaching practices, as it means that academics must consciously adopt teaching practices that foster deep learning (Smith and Colby, 2007: 209) so that when students exit the undergraduate programme, they are well equipped and at ease engaging in deep learning vis-à-vis research practices, and this learning has the potential to equip students to become active contributors to literacy practices within their discipline (McKenna, 2010: 16) and beyond. Creating meaningful learning opportunities has implications for students as "knowledge producers" (Bartholomae, 1985: 139) and will have a positive impact on the development of higher order thinking skills (HOTs) and, in turn, on students' problem-solving skills and ability (Clarence and McKenna, 2017: 44) as they are poised to enter the work world or postgraduate studies. Providing a foregrounding research engagement across the levels of the undergraduate programme will also help to demystify the research process and to break the stranglehold that may come with the introduction of research at postgraduate level.

Under the domain "engagement in research in the undergraduate programme", one core theme emerged: data collection experience.

Data collection experience

Specific modules may require primary, secondary or a combination of both types of data collection methods and analysis. Students' account of their research experience through the SURE industry-based projects indicated that they had actively engaged in both primary and secondary data collection methods:

> "We had to collect information through a survey on a home replacement meal for industry."
>
> "We had to conduct a literature review on certain ingredients."
>
> "We conducted a product observational study which led to product profile assessment in accordance with legislation."
>
> "We conducted an observational study in the food industry with COVID-19 protocol compliance."

While the above FGD excerpts allude to rich and varied data collection experiences, like Shanahan *et al.* (2015: 16), we advocate the need to include research-inspired content into the undergraduate curriculum, however, it must be implemented in a way that students are not overwhelmed with research projects. Faculty members must carefully plan these learning opportunities so that these fit the envisioned scope as an enabler of innovative and relevant curricula to help realise optimally prepared undergraduates. As more faculty members heed the call to include research at the undergraduate level, it becomes imperative for the faculty to support both staff and students in the pursuit of deep approaches to learning and teaching (Smith and Colby, 2007: 209).

Under the domain "experience of the research process in the industry-based collaboration", two themes emerged: collaborative learning and a deep approach to learning.

Collaborative learning

Quotes from the FGDs describe an interactive research process that involved collaborative teamwork and built upon interpersonal skills. Elements that appealed to the students were the strong group dynamics that were developed between the different role players during their shared experience while conducting the fieldwork.

> "My experience was quite interactive and also informative when we went out into the field and gathered data."
>
> "We were able to work as a complete team and also individually within this project."
>
> "It enhanced my interpersonal skills and teamwork."

Echoing Dewey's outlook to ground education in real experience (1938), the inclusion of industry-based research in the undergraduate programme was well-positioned to present students with an opportunity to immerse themselves in their authentic community setting, and to probe, ponder and provide solutions to real-world problems as experienced by participating community members. Data transcripts recount glimpses of strong and fruitful social interaction among role-players (Gillies, 2007) as well as ways in which barriers were overcome – the hallmarks of a well-founded social constructivist learning-teaching environment.

It must be acknowledged that authentic settings also introduce challenges; however, these student experiences also outline opportunities to learn and grow from their experience (Dewey, 1938).

> "I learned a lot…it was quite informative, but I did experience challenges here and there, whereby customers didn't want to take part in completing the surveys, they didn't have time… so that was quite challenging, but I did persevere, and I was able to complete all the questionnaires."

> "I spoke to the waitrons who made it easy for me so that their customers who usually come - their regular customers - would participate, so they spoke on my behalf."

> "Overall, it was a good learning experience and a good learning curve, forcing you to step out of your shell and your classroom and it forced one to engage with customers."

Students also alluded to a sense of the unknown when interacting with consumers and noted that while it was challenging to approach consumers, it was also enjoyable and different to the norm of being in a classroom. Immersed in their authentic research context, they became the active drivers of the classroom session, and their technique had to be refined and honed to adjust to their given situation and to elicit the required information from each unique potential participant. Students also had to be more prepared and informed to respond to any queries put forward by the participants during the data gathering sessions – this may have kept students more alert and actively attuned than being in the classroom where the environment is more predictable and sheltered.

Deep approach to learning

Synthesis of knowledge allowed for innovation. Students' experiences highlighted how they used techniques like triangulation of data sets to pursue innovative product development.

> "It allowed me to innovate and use information from the multiple sources: client brief, survey questionnaires, literature review, sensory evaluation to produce the optimal product."

Students also showed awareness of how different facets of the research process fulfilled unique roles in problem-solving and concept development.

> 'The one thing that helped me was the extraction of information from articles."

This is an important realisation and reflection for students, as they experienced first-hand that research has multiple components with different tools to mine data, each contributing rich layers to the research process. Undergraduate researchers will benefit from and need to develop core skills in the use of varied data collection tools as well as in the handling of data to meet their research objectives. Imbuing students with a sense of familiarity and ease with the multiple resources available in a researcher's toolbox will equip students for a more well-rounded and confident approach to research as they progress through their undergraduate level to postgraduate studies. In this process, the student becomes a co-collaborator in ways of knowing and knowledge creation in a discipline.

Personal involvement in the fieldwork may have made some students more accountable for their product development choices. The ideation process can overwhelm students as they may be swayed by trending international food items that lack a local fit and deviate from their industry-based brief; however, being so personally and actively involved and connected kept some students more grounded and focused on the multiple needs to be met to meet different stakeholder needs.

> "The trends analysis advised product development as it had to align with what consumers wanted."

> "Make sure that I stick to ... what is needed by the customers and in addition, we also tried our best to incorporate all … characteristics that will make the product desirable, including the trends and … to make the product cost-effective and more appealing to them."

The industry-based project was designed to elicit a collaborative, unique and creative student response, supported by well-founded research, thus aligning it towards a deep approach to learning (Kuh 2012; Smith and Colby, 2007: 208). The inclusion of purposively designed learning opportunities with multiple stakeholders need to be satisfied also helped to encourage and support a more collaborative and critically engaged undergraduate research experience (Kuh, 2012; Smith and Colby, 2007: 208).

Under the domain "key enablers of the research engagement", two themes emerged: Funding for undergraduate research and transfer of benefits of research skills in the undergraduate programme into higher levels of study.

Funding for undergraduate research

Support through funding was identified as a key enabler of undergraduate research engagement. It is well known that the successful execution of any research project depends not only on the efforts of the researcher, but also on the infrastructure available, including funding to conduct the research (Neema and Chandrashekar, 2021: 134). Key to this is the provision of funding, which is a norm to carry out postgraduate research, but often an oversight in enabling undergraduate research.

> "The student research budget covered everything, and it worked out perfectly."

> "The DUT-branded T-shirts provided institutional identity and created a sense of trust with consumers when collecting data."

Petrella and Jung (2008: 94) assert that one of the limitations of undergraduate research is monetary support. Undergraduate research requires investment from Higher Education Institutions, which was the case for the DUT SURE initiative. Apart from the continuous institutional support from the programme implementers, a seed fund of R30 000 (approximately $2 000) for research costs per project was provided for the execution of the project. In the absence of a budget, research can be constrained, yet a low-cost budget allowed for the proper execution of both research projects, implying that the provision of funding is necessary to expand research initiatives at the undergraduate level.

Transfer of research skills in the undergraduate programme into higher levels of study

Another key enabler of the research engagement was the vertical transfer of research skills in the undergraduate programme into higher levels of study. Research skills acquired in the Diploma programme facilitated the research process in the Advanced Diploma programme, typifying a vertical transfer of knowledge. Opportunity exists in developing research skills in the undergraduate programme by using Bruner's spiral curriculum model where learning takes place as a spiral upwards from basic to advanced concepts (Bruner, 1960).

> "The scaffolded approach of embedding research at the Diploma level provides a good foundation to support higher levels of study".

Student mentors from the Advance Diploma showed a cross-transfer of research skills to the students in the Diploma to enhance their research project.

> "The Advanced Diploma students helped with our writing for the value propositions, food styling and recipe editing, and mentors were available outside of class times for consultation".

Apart from the transfer of research skills, students who are exposed to research early in their careers are more likely to pursue postgraduate studies (Lopatto, 2004: 270). Forty percent of students from the diploma level pursued Advanced Diploma studies. These statistics may also prompt faculty to explore ways of including mentoring formally into undergraduate programmes to simultaneously include postgraduate students into the oversight of undergraduate work in support of a deep approach to learning, as well as helping to alleviate some of the direct workload on staff. Students participating in research at the undergraduate level must be afforded an opportunity to disseminate their work and to develop confidence in the value of their work (Walkington, 2015: 20). Several students from this study cohort took up the lecturer supported opportunity to present and share their research findings to multiple audiences both at DUT and other conferences, showing a strong student desire to disseminate their research. If well-structured and supported, undergraduate research could also lead to successful journal publications.

Several studies have documented barriers to research engagement at the undergraduate level, such as a lack of awareness of opportunities for undergraduate research, benefits of such research, and increased workload by faculty (Buffalari *et al.,* 2020: 53; Morales, Grinseki and Collins, 2017: 4). In our study, key barriers to research engagement from a student perspective included limited foundational research knowledge and the impact of emergency situations where the digital divide became more noticeable.

Limited *foundational research knowledge*

Students' responses affirmed that at the undergraduate level, an introductory module in research methodology should be taught, which would harmonise the embedding of research projects within modules and avoid cross-teaching of core aspects of research methodology by faculty being engaged in teaching discipline-specific modules.

> "Primary data collection methods must be taught at the diploma level."

> "I think students, they struggle in the department because they don't really have the background knowledge of research. So, I think introducing it in the first year would be beneficial to students."

Teaching the research process through an activity within a module conflict with the burden of teaching module content and the related increased workload to faculty which might limit research activities. An introductory module in research methodology through general education or STEM modules at a first-year level will provide universal and accessible opportunities to engage in research activities across undergraduate modules (Buffalari *et al.,* 2020: 54).

Impact of emergency situations

During both industry-based research projects, COVID-19 imposed data collection limitations and students had to adapt using hybrid methods of data collection. In addition, the digital divide created a steeper learning curve.

> "COVID-19 was a challenge for data collection which limited team interaction."

> "Online mode, computer literacy and network connectivity was a challenge."

For the pre-defined domain, "importance of embedding research in the undergraduate programme", knowledge transfer through the early initiation of research in the undergraduate programme emerged as a key theme.

Knowledge transfer through the early initiation of research in the undergraduate programme

Research should be embedded as early as possible in the undergraduate programme to benefit students in the synthesis of knowledge, develop people skills and prepare them for the world of work.

> "It is important and should be embedded early into the programme; it expands our knowledge, helps and us to discern better and stay updated with information."
>
> "I would recommend it to be embedded in the first-year curriculum to translate data into application."
>
> "I think it would be great if it can be introduced as early as possible so students can link theory to the practicals".
>
> "It builds your cognitive skills as well as research skills. I also think it builds character and people skills."
>
> "I think it is very important to start as early as possible, maybe first year so it can prepare us for us for the world of work."

Many studies have supported the proposal for greater inclusion of undergraduate research opportunities, emphasising the importance of early involvement (Thiry *et al.,* 2012: 260; Zimbardi and Myatt, 2014: 233; Buffalari *et al.,* 2020:52). It has been argued that research in the last year of the undergraduate programme, which is common, may be too late to receive maximum benefit from such practice (Thiry *et al.,* 2012: 260). In a study that reported students' experience of multi-year research engagement at the undergraduate level, students' personal and professional gain was highlighted, where students specifically gained confidence and developed their collaborative skills (Thiry *et al.,* 2012: 268). Moreover, students in this study also described how they developed not only the academic skills required for advancement in science, but also the behaviours and temperament required of a scientist directly relating to students' graduate destination (Thiry *et al.,* 2012: 260; Zimbardi and Myatt, 2014: 246).

Given the benefits and constraints associated with early research engagement, thoughtful consideration of strategies for implementation is required (Buffalari *et al.,* 2020: 52). Students made several suggestions as to how research can be embedded in the undergraduate programme. FGD participants felt strongly about research being embedded across all modules in the undergraduate programme and it should be supported with a budget provision. Participants also felt that research experience within a programme must be given a student voice through reflection, which will allow for continuous improvement. In addition, research tools and support must be provided.

> "We should include research in all modules."
>
> "Provision of a budget for undergraduate research."
>
> "Create an open platform on research experience within the undergraduate programme for students to communicate their views and experience. I think that would be much more interactive."

> "The undergraduate programme must have support for referencing, plagiarism and academic writing."

Conclusion

This study is not without limitations. The study focus was on a South African higher education context and the small sample size may limit the transferability of the findings. The thematic framework was used to analyse the data. A framework, such as the grounded theory, may have given us a different result. This study has several strengths worth noting. To the best of our knowledge, this is the first study to explore the student voice of undergraduate research experience in South Africa. Procedures for rigour and validity in the form of validity checks were done throughout the thematic analysis by the researchers.

While programmatic and institutional factors may either enable or constrain undergraduate research, the value of developing undergraduate research is widely accepted. This study focused on the reflection provided by student voices on the inclusion of research at the undergraduate programme level through an opportunity funded by SURE. Both the lecturers and the students involved in this process valued the lively learning trajectory unleashed by including the collaborative industry-based project work with a research component. To provide graduates with the cutting-edge adaptative skills they need for the world of work today and for postgraduate studies, course content and material must be created that challenge students and push their comfort boundaries – this will provide graduates with meaningful learning experiences. The positive feedback and experiences reported here via incorporating research into the undergraduate curricula must be used to drive uptake among more academics for the inclusion of research within the undergraduate modules taught. Such a move will require institutional and programmatic engagement to support undergraduate students with the rigours of becoming knowledge co-constructors needed for their graduate destination or continuation of postgraduate studies; it will also enable lecturers to reflect on their teaching practices aimed at improving their scholarship of teaching.

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Table 1: Thematic analysis of focus group discussions

Pre-defined domains	Themes	Summary	Representative quotes
Understanding of research and steps in research process	Process-orientated approach to research is measurable.	Research starts with an enquiry, it uses systematic methods in a process approach like designing and piloting surveys, collecting data from different sources to problem solve, within a set time frame. It includes recommendations to problem solve.	"Finding the methodology and a systematic approach to finding a specific outcome". "You must first know what you want to research about and what are the outcomes". "Conduct a survey, you mustn't collect your information or data from one source". "I would start with a hypothesis and then thereafter determine how I would arrive at my outcome". "Basic fieldwork - going out and physically collecting data from participants via surveys or questionnaires and piloting these". "Research has to be conducted within a set time frame". "First you need approvals from the Research Ethics Committee to conduct the study and consult with people supervising your research. Then after approval of your study, you recruit participants and gather data".
		Research needs topic brainstorming, planning, supervisor input, ethical approval, recruitment of participants, data collection and data analysis.	"We sourced articles and summarised the articles to gain understanding". "We analysed the data from the questionnaires to create new recipes". "An important step in the research process is to ask yourself questions like, is this relevant?" "An important step is to analyse the topic in depth to get a better understanding"
	Knowledge synthesis through data collection and handling	Using reputable primary and secondary data sources for finding out information.	"Finding information from a verified, reliable, and also reputable source of data". "Research is when you gather information about a particular topic that you are supposed to study or…Like…it's when you… find more information to back up what you already know or what you are trying to find out".
Engagement in research in the undergraduate programme	Data collection experience	Specific modules that required primary data collection and analysis	"We had to collect information through a survey on a home replacement meal for industry". "We had to conduct a literature review on certain ingredients". "We conducted a product observational study which leads to product profile assessment in accordance with legislation". "We conducted an observational study in the food industry with COVID-19 protocol compliance"

Pre-defined domains	Themes	Summary	Representative quotes
Experience of the research process in the industry-based collaboration	Collaborative learning Deep approach to learning	Interactive process, requiring collaborative teamwork and building interpersonal skills. Synthesis of knowledge allowing for innovation	"My experience was quite interactive and also informative where we went out into the field and gathered data". "We were able to work as a complete team and also individually within this project". "I learned a lot, so it was quite informative". "It enhanced my interpersonal skills and teamwork". "I learned a lot … it was quite informative, but I did experience challenges here and there, whereby customers didn't want to take part in terms of completing the surveys, they like don't have time … so that was quiet challenging, but I did persevere, and I was able to complete all the questionnaires". "Overall, it was a good learning experience and a good learning curve, forcing you to step out of your shell and your classroom and forcing you to engage with customers". "I spoke to the waitrons who made it easy for me so their customers who usually come, their regular customers would participate, so they spoke on my behalf". "It allowed me to innovate and use information from the multiple sources; client brief, survey questionnaires, literature review, sensory evaluation to produce the optimal product". "The one thing that helped me was the extraction of information from articles". "The trends analysis advised product development as it had to align with what consumers wanted"
Key enablers of the research engagement	Funding provision Transfer of research skills in the undergraduate programme into higher levels of study	Budget provision enables research at undergraduate level and provides institutional identity. Research skills embedded in the Diploma programme facilitated the research process in the Advance Diploma programme. Student mentors from the Advance Diploma showed cross transfer of research skills to the students in the Diploma research project.	"The student researcher budget covered everything, and it worked out perfectly". "The DUT branded T-shirts provided institutional identity and created a sense of trust with consumers when collecting data". "The scaffolded approach of embedding research at the Diploma level provides a good foundation to support higher levels of study". "The Advance Diploma students helped with our writing for the value propositions, food styling, recipe editing, and mentors were available outside of class times for consultation".

Pre-defined domains	Themes	Summary	Representative quotes
Key barriers to research engagement	Limited foundational research knowledge Emergency situations	Limited research knowledge upon entry to university COVID-19 imposed data collection limitations making the digital divide noticeable.	"Primary data collection methods must be taught at the diploma level". "COVID-19 was a challenge for data collection which limited team interaction". "Online mode, computer literacy and network connectivity"
Importance of embedding research in the undergraduate programme	Knowledge transfer through the early initiation of research in the undergraduate programme	Embed research as early as possible in the undergraduate programme to benefit students in the synthesis of knowledge	"It is important and should be embedded early into the programme, it expands our knowledge and helps us to discern better and stay updated with information". "It builds your cognitive skills as well as your research skills. I also think it builds character and people skills". "I would recommend it to be embedded in the first-year curriculum, to translate data into application". "I think it would be great if it can be like introduced as early as possible so students can link theory to the practical". "I think it is very important to start as early as possible, maybe first year so it can prepare us for the world of work". "I think students, they struggle in the department because they don't really have the background knowledge of research. So, I think introducing it in the first year would be beneficial to students"
Suggestions as to how research can be embedded in the undergraduate programme.	Embedding across modules Budget provision Research tools access and support Reflective learning	Research should be included across modules within a programme with budget allocation and access and support to research tools. Reflective learning opportunities should be supported for continuous improvement	"We should include research in all modules". "Provision of a budget for undergraduate research" "The undergraduate programme must have support for referencing, plagiarism and academic writing". "Create an open platform on research experience within the undergraduate programme, for students to communicate their views and experience. I think that would be much more interactive"