Mechanical engineering students' contribution to their work placement learning trajectories

TIYAMIKE NGONDA[1]
Cape Peninsula University of Technology, Cape Town, South Africa
CORRINNE SHAW
BRUCE KLOOT
University of Cape Town, Cape Town, South Africa

This article reports on a qualitative multi-case study conducted to investigate how work placement contributes to the learning of mechanical engineering students. The study collected data from 34 mechanical engineering students undergoing year-long placement. It found that work placement students' proactive behavior influenced their learning trajectories. Proactive students experienced increasing participation as they moved from the periphery to engaging in active participation in their work community and were exposed to meaningful and complex work. On the contrary, those students who were passive seemed to stagnate in both participation and work performance. As a result, they remained peripheral participants for the entire placement. The findings are interpreted to suggest that universities need to help students manage their participation to improve their work placement learning. Additionally, they need to monitor changes to students' participation in work activities and their work complexity.

Keywords: Work placement, proactivity, learning trajectories, mechanical engineering, qualitative study

Work placement represents a significant opportunity for engineering students to gain practical knowledge and professional skills, thereby enhancing their employability (Agwa-Ejon & Pradhan, 2017). It is a structured period of work-based learning for students to gain occupationally relevant work experience as part of their curriculum (Smith et al., 2009). The implementation of work placement varies considerably among engineering programs. In some cases, work placement is practiced as cooperative education, alternating full-time employment and full-time traditional university study (Main et al., 2020). Another variation of work placement is the 'sandwich degree', which incorporates nine to twelve months of supervised work placement in the penultimate year, with students returning to university after their work placement. In South Africa, students at traditional universities have very short vacation workplace training periods, while students at universities of technology undertake six months of supervised work placement in their final year (Ziegler et al., 2020).

Despite these differences, most researchers agree that several positive career-related outcomes accrue for work placement students (Inceoglu et al., 2019). Brooks and Youngson (2016), Silva et al. (2018) and Jackson and Collings (2018) reported that work placement has a positive impact on actual graduate employment. Jackson (2017) explained that this is accurate for initial employment, with work placement students being more likely to be employed soon after graduating than non-work placement students. Winberg et al. (2011) suggested that this might be because work placement provides structured employment pathways. This is corroborated by Jacobs (2015), who found that more than 50% of work placement students who participated in his study were employed by the companies where they undertook their work placements.

In addition to career-related outcomes, several researchers have also reported positive developmental outcomes of work placement. Little and Harvey (2006) found that work placement develops students'

[1] Corresponding author: Tiyamike Ngonda, ngondat@cput.ac.za

interpersonal skills such as oral and written communication, the ability to deal with clients, and networking skills. Other researchers have established that work placement increases students' personal skills such as self-confidence, work self-efficacy, maturity, responsibility, and adaptability (Kopsidas et al., 2013; Little & Harvey, 2006; Lock et al., 2009; Reddan, 2016; Varghese et al., 2012).

Snowden (2018) proposed that to understand the impact of work placement, one should go beyond evaluating the career-related and developmental outcomes. He suggested that there is a need to consider other factors and their contribution to these outcomes. Factors such as the culture of the workplace, industry mentors, co-workers, type of work done, students' attitudes and prior work experience have been reported as influencing outcomes of work placement (Deketelaere et al., 2006; Ngonda et al., 2019; Snowden, 2018; Zehr, 2016). However, there are still gaps in the literature as to how these factors contribute to particular outcomes. The aim of this research was to explore how students contribute to the outcomes of their work placement by answering the research question: How do mechanical engineering students contribute to their learning trajectories during work placement?

A learning trajectory is the developmental progression of a student's learning over time (Maloney et al., 2014). It comprises a learning goal for the student, levels of thinking and acting, and instructional activities that promote the required progression (Clements et al., 2020). Dahlgren et al. (2006) demonstrate that although the concept was developed in mathematics education, it could be applied in other disciplines such as political science, psychology and mechanical engineering. When viewed from the perspective of learning trajectories, work placement helps students transition from being senior students to novice workers. This transition entails a progressive change from peripheral to active participation. Additionally, it involves increasing autonomy, from working under close supervision to the self-directed execution of work tasks.

THEORETICAL PERSPECTIVE

To include both cognitive and social aspects of learning (Jarvis & Parker, 2005), this study was informed by two theories, legitimate peripheral participation (Lave & Wenger, 1991) and social cognitive theory (Bandura, 1997).

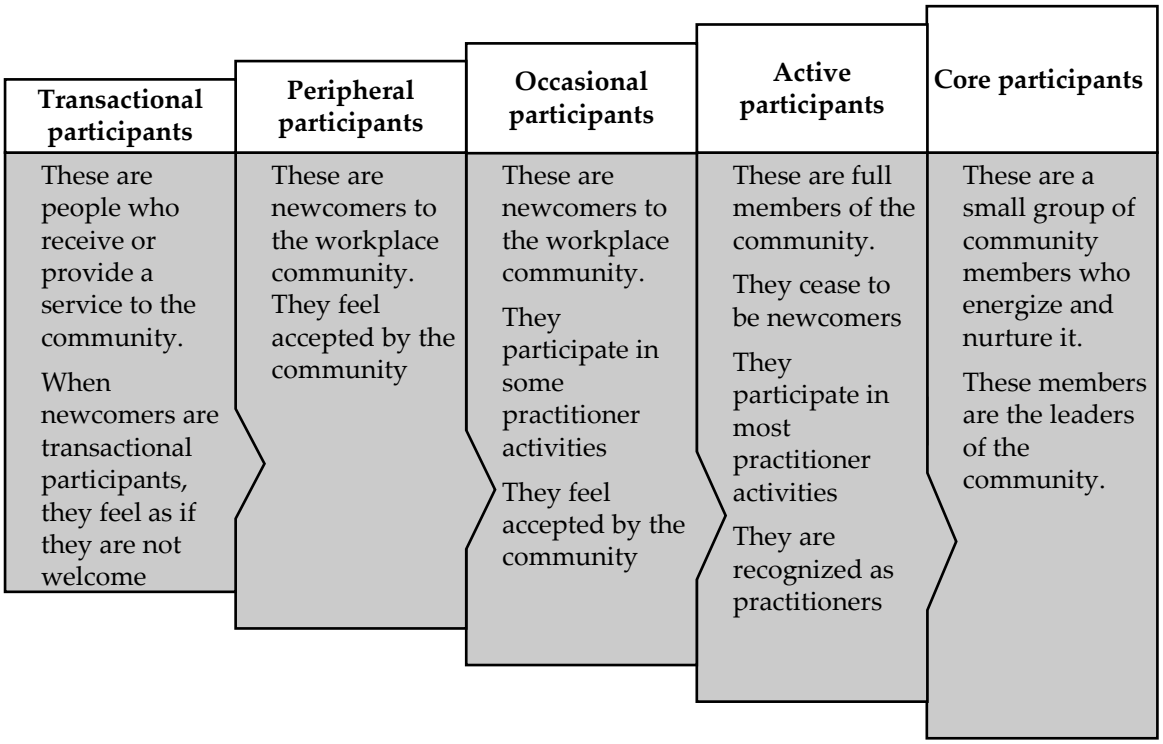
Legitimate peripheral participation shifts the focus of learning as the interaction between the students (newcomers) and their industry mentors (teachers) to the interactions between students and the entire work community (community of practice). Lave and Wenger (1991) explained that legitimate peripheral participation refers to how newcomers become old-timers. This collaborative learning process is premised on the community of practice accepting newcomers. This acceptance is required to access the shared repository of resources such as experiences, stories, cognitive and physical tools, and ways of solving problems.

It is the community's acceptance that gives the newcomer authority to enter the community. If the community of practice does not accept a person, they might render a service or receive service from the community but remain an outsider or a transactional participant (Karalis, 2010). Lave and Wenger (1991) pointed out that the term `legitimate' defines belonging, indicating that, unlike a transactional participant, the legitimate peripheral participant is recognized by the community as one of their own.

Lave and Wenger (1991) further explained that learning through participation entails changing location, participation levels, dynamics, as well as developing a professional identity. In 1991, they suggested three levels of participation: peripheral, full, or central participation. In later unpublished work, Wenger added two more levels to the concept of participation levels (Karalis, 2010). Figure 1

illustrates the progression of participation once a newcomer joins a workplace community as described in Ngonda et al. (2022), Karalis (2010) and Lave and Wenger (1991).

FIGURE 1: Progression of newcomer participation within a community of practice.



As new members of a community of practice become competent, their involvement in the community's socio-cultural practices increases (Lave & Wenger, 1991). This integration is facilitated by progressive mastery in using artefacts that are common to the community (Holland & Lave, 2009). In legitimate peripheral participation, learning constitutes increasing engagement in communities of practice and the growing complexity of allocated tasks. Legitimate peripheral participation conceptualizes learning more as doing, something that concerns the whole person acting in the world, than as a cognitive process (Lave & Wenger, 1991).

It is important to note that participation in the community of practice is contested, influenced by political, economic, cultural, and historical factors (Holland & Lave, 2009). For example, belonging to a certain cultural or social-economic group or having a certain life history may make it easier for some newcomers to participate in workplace communities than others. Thus, contestation arises in the workplace between the imperatives of newcomers and community power relations. These contestations can compromise work placement students' participation and limit the possible learning opportunities in particular work contexts.

Social cognitive theory focuses on agency to explain the behavior of students that is not prompted by their work environments. Agency in this context refers to a person's capacity to intentionally influence their behavior and physical and social-structural environment (Bandura, 2001). According to social cognitive theory, people, including work placement students, are not merely destined to respond to environmental events (Bandura, 1999). They choose which environmental events to observe and the

meaning conferred on them, thereby influencing their own experiences (Bandura, 2001). For instance, some work placement students proactively choose which work colleagues to associate with and how to act in the workplace and, in so doing, influence their workplace experiences.

Another concept from social cognitive theory, self-efficacy, links students' work-based learning processes and their perceived competence changes. Self-efficacy refers to one's belief about one's capacity to handle particular tasks (Bandura, 1999). Bandura advised that self-efficacy is not generic, as is the case with self-confidence, because it is specific to particular competencies. For example, students may think they can handle any word processing task but feel utterly incapable of using a finite element analysis computer program. According to Bandura (2001), low self-efficacy can be debilitating for students as it may influence them to act in ways that are detrimental to achieving learning outcomes. One such negative result of low self-efficacy is task avoidance. Conversely, he explained that high self-efficacy can enhance students' potential to achieve learning outcomes. Students with high self-efficacy tend to be proactive and thrive on tackling challenging tasks.

Bandura (1997) contended that self-efficacy influences how a person responds to challenging situations. He explained that when faced with a difficult task, self-efficacy enables one to exercise control over anxiety. He argued that high self-efficacy individuals are likely to experience excitement and eagerness to get started rather than be anxious about their capacity to complete tasks. Conversely, when faced with similar challenging tasks, individuals with low self-efficacy focus on their deficiencies and worry about events that rarely happen, thereby impairing their functioning.

RESEARCH METHODS

This study employed a qualitative multi-case study approach to understand mechanical engineering students' perceived contribution to their work placement learning trajectories. It was underpinned by an interpretivist epistemology as it sought to understand the different constructions and meanings that students place on their work placement experience.

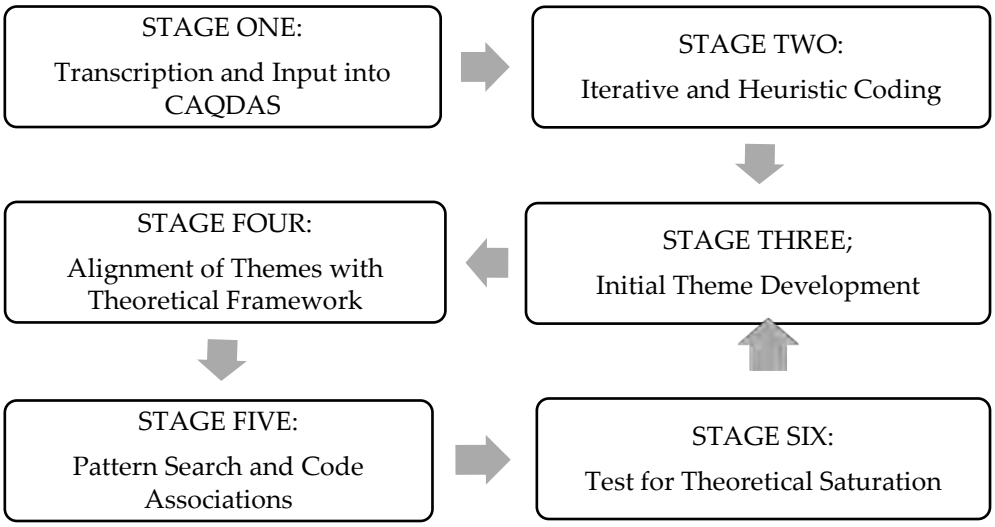
Ethical Considerations, Participant Selection and Data Collection

The head of the relevant Department of Mechanical Engineering at a university of technology in South Africa granted permission to observe and interview their students who were undergoing placement. In addition to this permission, institutional ethical approval was also obtained. Thereafter, invitations to participate in the study were sent to 302 mechanical engineering students. The students were undertaking year-long placement at 47 companies in ten different industry sectors. From the respondents, the authors selected 34 students based on the diversity of their experiences as inferred from the industry sectors and the author's field observations. Qualitative data were collected from these 34 students using semi-structured interviews and document analysis of their work placement logbooks and evidence portfolios. Multiple data sources and collection methods were used to promote the credibility of the data making and collecting processes (Patton, 2015).

Data Analysis

The semi-structured interviews were transcribed and prepared for analysis with the student as the unit of analysis. The study combined the generic thematic analysis approach of Bryman (2016) with an interactive data analysis process developed by Miles et al. (2014). The six stages of this analysis are illustrated in Figure 2 below.

FIGURE 2: The six-step thematic analysis procedure used in the study.



Firstly, the transcriptions were input into computer-assisted qualitative data analysis software (CAQDAS) and read for emic understanding. Twelve cases representing the diversity of experiences present in the study were selected for initial coding. In the second stage, an iterative and heuristic coding process was carried out to arrive at descriptive codes. The codes from each iteration were compared with those from the previous iterations to check for the stability of the codes. The third stage comprised a second cycle of coding to develop tentative themes. Descriptive codes from the first cycle were revised into higher-order codes through categorization, pattern-seeking, and case comparison. The data display tools of the CAQDAS were used in this stage.

The fourth stage was an iterative revision of the second-cycle codes. The codes were renamed for clarity drawing on deductive comparison with concepts identified in the theoretical perspective. The fifth stage consisted of uncovering associations among the secondary codes. This process was facilitated by the data visualization tools of the CAQDAS. The final stage was a decision gate for inductive thematic saturation. Additional cases were coded one at a time. If new codes emerged that did not align with the existing themes and subthemes, the analysis process restarted at stage three. On the other hand, if new codes did not emerge, indicating a stable theme and subtheme structure, it was assumed that inductive saturation had been reached. In this study, inductive saturation was reached after seventeen cases. Even so, the remaining seventeen cases were coded and added to the analysis to facilitate the discovery of associations among the various subthemes.

FINDINGS

Two overarching themes were identified representing the student contributions to their learning trajectories during work placement learning. Each theme and its constituent subthemes are shown in Table 1.

TABLE 1: Themes and subthemes that emerged in analysis stage 5.

Overarching theme	**Subthemes**
Student characteristics	High engineering task self-efficacy Low engineering task self-efficacy High agency-proactivity Low agency-passivity Still a student-not yet competent Occupationally competent
Student learning trajectories	Increasing participation Improving performance Stagnant participation Stagnant performance

Student Characteristics

The students' engineering task self-efficacy (ETSE), agency and occupational competency were inextricably linked. These collectively influenced the students' learning trajectory. For instance, the findings suggest that high ETSE might lead to high agency, expressed as a proactive solicitation of guidance and work. This positively influenced the quality of their work placement experience and quickened the pace of their learning. Proactive students seemed to be exposed to more meaningful work as they articulated their learning needs and approached industry mentors when they needed guidance. The experiences of Dineo[2] demonstrate the identified association between students' proactivity and growth in learning trajectory:

> I stood up and told my mentor. I asked him if I could work outside with the guys. He did not mind because, to him, it is like I'm learning new things. So, I went to work with the guys. After two weeks, I went to him again. He told me, "I love what you are doing", then he grouped me with somebody else. After that week, I went to him again, and he grouped me with somebody else. He was getting used to the system that I'm now working there. I started getting invites to meetings, cost meetings, planning meetings and everything. I started being treated well in all those things. And then I started travelling to other plants.

Another student, Tsepiso, explained that he requested to spend some time in the workshop to learn hand skills. Before this, he worked in the engineering design office.

> I told him [my mentor] that I have never been to an engineering company, so I would like to gain [workshop] skills. I said I would like to acquire them so that I can be a proper technician. We understood that I would spend a bit of time in the workshop to learn all those things. So basically, the artisan would call me and show me what I needed to do.

These findings suggest that most industry mentors preferred students to take charge of their learning through proactive solicitation for work and guidance. Most students who solicited advice or work from their assigned mentors reported that they obliged and provided them with the requested exposure. It

[2] Pseudonyms are used throughout.

is worth noting that proactive students did not limit their solicitation of guidance to their industry mentors. If the mentors were unavailable, they sought help from co-workers. For example, Johannes described how he routinely sought help from co-workers when his industry mentor was not available:

> If you ran into a situation and couldn't get hold of your mentor, you went to a junior project manager and [he] helped you. Senior project managers would also help you, but their time was limited, so their help wasn't as frequent as the junior project manager's.

Conversely, other students were passive in seeking workplace support and expected industry mentors to initiate work allocation or to provide guidance. When the mentors were not forthcoming, students continued with the work they had been assigned, even when they thought it would not of any benefit. This passive attitude resulted in stagnation in their learning trajectory. An example of this is Thomas, who expected the industry mentor to approach him for work assignments, just as was the case at university:

> I expected to work daily with the engineers and the fitters, fixing stuff or asking them questions. I expected to be getting some assignments where they tell me you need to know. Let's say I ask you to find out how this machine works. Then at the end of a week or two, come and ask you to explain to them how the machine works.

Some students attributed their passivity to disempowerment. These were either international students or those whose placement was delayed for an extended period. Once they secured a placement, they restrained themselves from acting in a manner that would jeopardize their work placements. For example, Thomas and Martha claimed that scarcity of work placement contributed to their passivity. Martha explained the rationale behind knowingly accepting work that would not provide valuable experiences:

> I would say it was desperation. I was looking for [work placement] for six months before they offered me this job. You just put your thoughts [reservations] behind and say to yourself that you will figure out things later while you are in here.

Despite this, there were positive outcomes, as evidenced by the experiences of Thomas and Martha. It emerged from their interviews that they gained valuable skills such as teamwork, communication skills, and how to behave in the workplace. However, these students also recognized the lack of technical engineering knowledge as a shortcoming in their work-integrated learning (WIL). Consequently, they lacked confidence in their abilities and doubted if they would perform as technicians without other internship experiences. For example, Michael lamented the possibility that his inadequate experience would have lingering negative consequences long after graduation:

> I will graduate, but I didn't get much exposure because after a year, I'm supposed to claim to be able to work [at] any place, but you don't get that confidence when you walk out of [Company 16] after a year of in-service. You still feel like you still need to get another chance of another training somewhere.

In summary, the findings suggest that mastery experiences, experience gained from completing challenging tasks, lead to high ETSE, which facilitates high agency. High-agency students tended to be afforded meaningful work, providing mastery experiences that further reinforced their high ETSE. Conversely, work of narrow scope seemed to lower the student's ETSE. Low ETSE was associated with

low agency. Students with low agency tended to be assigned token work, which further diminished ETSE.

Student Learning Trajectories

As indicated in Table 1, the findings showed two dynamic student learning trajectories and two stagnant student learning trajectories. It was clear that there was an association between efficacious learning and the two learning trajectories, improving student participation and increasing student performance. The study found two forms of increasing participation: from peripheral to active or occasional to active. Increasing participation required initiation and facilitation by an influential current member of the community of practice, such as a high-capacity mentor. For example, some mentors, such as Joseph's mentor, delegated their work tasks to their students.

> He [my mentor] is the person who is responsible for everything relating to aftersales service. He makes sure that I get as many practical projects as possible because he understands what is needed. He usually gives me some projects that he was supposed to run just to let me have more knowledge, not just practical work, but also office work. He says I also need to understand office work so that I can be a supervisor like him one day.

On the other hand, increasing autonomy in working and growing complexity of assigned tasks reflected increasing student performance. In most cases, increasing participation and improving performance were concurrent processes. For instance, Tsepiso recounted how he progressed from assisting an artisan in assembling a factory carousel to managing projects:

> My first few days were in the workshop. I was working with a qualified artisan. We had to work on assembling the massive carousel I was talking about. The artisan would call me and show me what I needed to do. He would say, "Take the six-millimetre hole that you want to tap. First, you have to drill a five-millimetre hole, then tap it." He showed me how you drill and how you mount the piece. I moved to another department. I started by doing manufacturing drawings and later laser-cutting parts. Then I moved up to working with other engineers in designs. For massive design projects, we would split them into parts. So, every engineering student, seniors and juniors, would work together on the same project.

Some students' narratives indicated that, over time, their proficiency in performing work activities improved from slow and error-prone performance to performance that they perceived to be comparable to that of their colleagues. In most cases, the perceived performance growth was tied to increased involvement in the work community. For example, Alice narrated how she was initially assigned token tasks to pass the time and was excluded from participating in breakdowns to being a valuable maintenance department member. Her experiences show that she moved from being a peripheral participant to an occasional one:

> The first week I was bored because they gave us books to read. Our PPE did not arrive, so we couldn't go to the shop floor to do anything, so we had to do everything office-based. They gave me many drawings to do. I had to do drawings, like, the entire day. Everybody who had projects would ask me to do their drawings. The maintenance department abused me in that area, like AutoCAD. The maintenance department needed drawings like every day, so you had a stack of them. When there was a big breakdown, they did not take you with them. They were so focused on the breakdown that they just took the skilled people to fix that thing as soon as possible. And they would give you some other work to do in the meantime.

The students had a role in sustaining the dynamic learning trajectories, thereby influencing the enabling learning environment's sustenance. The learning environments responded to successful student performance by providing them with more performance opportunities. For example, Tsepiso explained how his ability to perform work activities successfully led to a dynamic learning trajectory:

> I was the lead on some site works. I would go there independently, just like other engineers. I wanted to be involved in all aspects of the design. That is why, within a few months, I already had projects of my own because I demonstrated the ability to do all those things and be responsible at the same time.

Conversely, unsuccessful performance halted the growth of learning trajectories, as George's experience showed. He explained how his failure to manage a work team led his mentor to appoint someone to assist him:

> When he said I must supervise it was challenging for me because I did not know how to supervise. This job was delayed because I did not know the job. I told my mentor that I didn't know this job. He gave me another person who knows the job to assist me with supervising the team then I learnt from him.

Furthermore, the analysis showed an association between inadequate learning opportunities and stagnation in participation and performance. In such cases, students had a slight variation in tasks during their placement periods. For instance, some did draughting, operating production machines and quality inspections. As indicated earlier, this on its own was not a problem because the proceduralization of repeated performance improved their task proficiency. While their performance became faster and less error-prone, once their ETSE beliefs became established, further performance did not improve those beliefs and the challenge associated with performance diminished. For some students, performance became boring. A typical case of a learning environment that restricted learning growth was that of Peter. He explained that he spent his entire placement doing draughting work for his sponsor "I could say eighty per cent of the work I did was drafting. I was drawing. For the rest, I compiled technical installation manuals for the systems and compiled a technical database for the parts I drew."

In all cases, stagnant performance was due to transactional participation, focusing on productive activities removed from the workplaces' core mechanical engineering activities. Students who were involved in this way were not peripheral participants because they performed either support or ancillary tasks. For instance, Peter (above) could not claim to have become closer to his sponsor's core business, which was the design of braking systems for mining plants, since he fulfilled only a draughting function.

DISCUSSION

In this study students' proactivity or passivity was found to influence their work affordances and consequently their learning trajectories in the workplace. The findings show that proactive students were afforded more meaningful work and received more guidance than passive students. They also tended to participate in their work community's core activities, such as high-profile projects. On the other hand, the findings suggest that the absence of a proactive approach impacts the quality of student performance and participation. This might be because industry mentors are often busy with their primary responsibilities and this constrains their ability to determine students' learning needs. Proactive students were found to have an advantage over passive students as they make their needs

known to industry mentors. As the mentoring of work placement students is a secondary role for most industry mentors, students' articulation of their learning facilitates the industry mentors' functioning. This finding is consistent with literature which suggests that in most workplaces, proactiveness is considered an indication of initiative, a valued attribute (Sapp & Zhang, 2009) and a sign of commitment (Eraut, 2004). Molloy et al. (2014) explained that proactiveness enabled students to develop work networks beyond their mentors. It allows work placement students to benefit from the knowledge of the broader work community in additional to the insights of mentors. An added benefit of this more extensive network is that they experience a faster integration into the work community (Ashforth et al., 2007).

The study has further shown that the students' learning trajectories influence their perceptions of the quality of their work placement experiences. Students who reported that they stagnated as transactional participants believed that they had inadequate work placement experiences. These students thought that their host companies assumed they were there to earn an income. This is consistent with the findings in Mutereko and Wedekind (2016) that some companies employ work placement students as a source of cheap labor. Lave and Wenger (1991, p. 76) maintained that students who are considered a source of cheap labor are "put to work in ways that deny them access to activities in the arenas of mature practice."

It is clear from the findings that it was not the use of students as 'cheap labor' that was a problem, but rather stagnation as transactional participants. In most cases, students initially accepted non-technician-level positions with the expectation that they would be moved to technician-level positions once they had settled at their placement companies. In this case, the students' expectations are consistent with how guided performance is conceptualized in traditional and cognitive apprenticeship (Brown et al., 1989; Collins & Kapur, 2014; Lave & Wenger, 1991). In both traditional and cognitive apprenticeships, the preferred route is to start with low-skill activities and progress to more complex activities, depending on growing proficiency.

Some of the students who remained transactional throughout their work placements lost confidence in their potential to develop as mechanical engineering practitioners. They spoke of leaving the mechanical engineering sector altogether because of this perceived snub. This finding gives credence to one of the most significant criticisms of work placement, particularly in the South African context, that the quality of some of the work placement experiences could potentially compromise the student's learning and employment outcomes (Mutereko & Wedekind, 2016). Thus, when companies employ work placement students in low-level jobs, it devalues the impact of work placement.

It is evident from the findings that the pre-placement programs and the student progress monitoring systems should account for the contribution of students' dispositions to their work placement experiences. It would be beneficial to work placement students if they were assisted in finding out if they were likely to be proactive or passive in their work-based learning interactions. The universities would then assist those students who demonstrate passive tendencies to develop proactive dispositions or to manage themselves so that their disposition does not compromise their learning. The study recognizes that it might be impractical to assess and offer students behavioral help because of the administrative burden in dealing with a large number of students. Massification of higher education implies that work placement coordinators are already overworked in most universities, having to place and monitor an ever-increasing number of work placement students (Ch'ng & Tang, 2018). However, at the very least, universities could offer work placement tools to enable students to explore their dispositional tendencies and provide guidelines on ensuring tendencies do not compromise learning

during work placement. Additionally, it would be beneficial if work placement coordinators developed tools to track students' learning trajectories. Monitoring changes or lack thereof in the tasks that work placement students are exposed to, enables stagnation in the students' learning trajectories to be identified before any adverse outcomes.

As with all studies, the choice of the research approach and the employed research methods imposed some limitations on the study. The authors could not generalize the findings beyond the context described in this article or determine the strength of the association between student proactivity and work placement students' learning trajectory. Therefore, future work should consider following a quantitative approach to find statistical associations between variables representing the relationship between student characteristics and their learning trajectories.

CONCLUSIONS

From this study, it emerged that the students' agency, reflected in passivity or proactivity, influences their learning trajectories during work placement. The findings are interpreted to suggest that proactive students experience increasing participation in the work community and are exposed to work activities of growing complexity. As a result, they move from being peripheral to active participants of the work community. On the other hand, passive students stagnate in both participation and the complexity of work they are exposed to. Such students spend the entire placement as transactional participants and are likely to become despondent.

This has significant implications on how universities design their work placement programs and how work placement coordinators monitor student progress. Universities need to assist students in discovering whether they have a passive or proactive disposition. Those students with passive tendencies need assistance to manage their engagement with co-workers to lessen the impact of their disposition on their work placement experience. Also, work placement coordinators need to develop assessment tools that help them monitor changes to the complexity of the work their students are exposed to.

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