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TEACHERS' PERCEPTIONS OF USING THE BLENDED LEARNING APPROACH FOR STEM-RELATED SUBJECTS WITHIN THE FOURTH INDUSTRIAL REVOLUTION

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Abstract. *Globally, as society enters the Fourth Industrial Revolution, we require a transformation in pedagogy. Science, Technology, Engineering and Mathematics (STEM) related subjects are vital to succeeding within the Fourth Industrial Revolution. To provide quality STEM education, teachers' perceptions related to the teaching and learning of STEM-related subjects is essential to understand. This qualitative research took place at one university in KwaZulu-Natal, South Africa and explored teachers' perceptions of using blended learning for STEM-related subjects. Wenger's Communities of Practice Theory framed this research. Data were generated from workshops and semi-structured interviews. The results of this research indicated that blended learning is impeded by the lack of technology-based tools; is hampered by teacher professional development; offered the use of virtual hours for consultation and feedback and increased engagement and collaboration within STEM-related milieus. These results provide a glimpse of what teachers perceive regarding the use of blended learning for secondary school mathematics and technology. Globally, these results have relevance when considering the importance of teachers' perceptions of using blended learning for STEM-related subjects, as society embraces the Fourth Industrial Revolution.*

Keywords: *blended learning, communities, practice, fourth industrial revolution, mathematics teaching, qualitative, STEM-related subjects, STEM teachers, technology teaching, technology-enabled learning.*

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Introduction

As teachers embrace the Fourth Industrial Revolution (4IR) to promote effective teaching and learning, teachers need to be exposed to and be well acquainted with using technology-enabled pedagogy. Technology-enabled learning refers to the effective incorporation of technology-based tools within educational milieus to scaffold students' learning (Ertmer & Ottenbreit-Leftwich, 2012). Research (Borko, 2004; Darling-Hammond, 2017) have maintained that professional development for teachers is essential for transforming pedagogy, advancing educational milieus, using innovative tools and improving learning outcomes.

Professional learning may take place in formal settings (Timperley, 2011) or via collaboration and mentoring between colleagues (Little, 2012). However, for productive and successful teacher professional development, professional development must be rooted within the teachers' teaching subject (Darling-Hammond et al., 2009).

The teachers/participants within this research were invited to attend informative workshops focusing on using the blended learning approach within their teaching subjects, i.e. mathematics and technology (STEM-related subjects). This research reports on an exploration of STEM teachers' perceptions of using the blended learning approach for STEM-related subjects within the 4IR.

Science, Technology, Mathematics and Engineering

Research (Büyükdede & Tanel, 2019) proposed that an essential factor for countries to contemplate to improve their economy and become independent economically is the production of technology. Technology production is a multifaceted pursuit (Seck, 2015) and is initiated by encouraging and supporting students to pursue careers within Science, Technology, Mathematics and Engineering (STEM) related fields. However, in most countries, the number of students registering in STEM-related disciplines have decreased at

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the secondary and tertiary education level (Fadzil et al., 2019). This is discouraging since STEM education is known to advance characteristics that are considered within education to be 21st -century skills (Timms et al., 2018).

A possible reason for the decline in interest in STEM-related subjects could be because students find STEM-related subjects challenging to understand or due to ineffective pedagogies for teaching and learning, shortage of academic support or out-dated and monotonous teaching practices (Hains-Wesson & Tytler, 2015; Fadzil et al., 2019). Nevertheless, technological changes have transformed the workplace, and STEM knowledge and skills are needed for employment and professions as we embrace the 4IR (Makgato, 2019).

Fourth Industrial Revolution

The Fourth Industrial Revolution is described as the merging of the physical and virtual world, creating a more globally connected society which has transformed society and the way we live (Schwab, 2016). As novel technologies emanate virtually and current occupations are replaced, society will need to modify and acquire different skills (Makgato, 2019). Knowledge and skills acquired during STEM education would be of benefit within the 4IR.

The ability to address challenges within the 4IR such as climate change, poverty, technology development, overpopulation and food security will depend on how enlightened society is in STEM-related subjects (Fadzil et al., 2019). For teachers of STEM-related subjects, knowledge of content is not the only requirement for developing well-qualified students as teachers ought to have the essential abilities to ensure effective teaching and learning of STEM-related subjects (Büyükdede & Tanel, 2019). Additionally, to be successful within the 4IR, a necessary approach for progression would be technology development (Seck, 2015). Students would need to be exposed to and encouraged to learn by using technology-enabled pedagogy to enhance the development of technology within educational milieus.

Teachers would also need to be proficient in using technology-enabled pedagogy. One innovative technology-enabled pedagogy that teachers may promote within contemporary educational milieus is the blended learning approach.

Blended Learning Approach

Blended learning is a new model that incorporates the benefits of conventional teaching and the use of Information and Communications Technology (ICT) within educational milieus (Lalima & Dangwal, 2017). The blended learning approach encompasses learning via online devices as well as conventional contact mode of teaching and learning (Jong, 2016). This type of pedagogy aims to initiate a mixture of online educational resources and prospects for online interaction, together with traditional classroom methods (Lalima & Dangwal, 2017).

The role of the teacher is an important aspect to consider within the blended learning environment. The teacher's role ought to be that of a facilitator or guide focusing on using student-centered pedagogy to support students as they reflect, learn, problem-solve and pose questions (Jong, 2016). Moreover, in this digital revolution where science and technology play an essential role in our lives, education in STEM-related subjects is facing challenges (Fadzil et al., 2019). The swift development in teaching and learning using online platforms and the necessity to improve the facilitation of STEM subjects motivates for the blended learning approach (Hains-Wesson & Tytler, 2015). Thus, it is essential to explore teachers' perceptions of using the blended learning approach for STEM-related subjects within the 4IR.

Exploring the Theory of Communities of Practice

This research was framed within the ambits of Wenger's (1998b) Communities of Practice theory. The Communities of Practice (CoP) theory is a social theory of learning that has its own set of assumptions and focus whereby the central unit of analysis is the CoP (Graven & Lerman, 2003). A CoP advances around phenomena that are of interest to individuals (Wenger, 1998a). Besides, a CoP tends to generate a milieu of reflection, understanding and feedback that enhances the rapport between researchers and practitioners such that the knowledge created is more valuable and significant (Hearn & White, 2009).

Wenger's (1998b, p. 4) CoP theory is founded on four principles: people are social beings; knowledge concerns

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'valued enterprises'; knowing is about engaging in the world and meaning is what learning yields. This theory maintains that CoP is formed by individuals who participate in the process of shared learning within a public domain of human effort. Thus, CoP comprises groups of individuals who share an interest in something they take on and through collaboration, they learn how to improve what they undertake (Wenger & Wenger-Trayner, 2015). Furthermore, within the CoP theory, four components of learning are identified, i.e., meaning, practice, community and identity (Wenger, 1998b).

The link between the CoP theory and this research is explained as follows: CoP has a shared domain of interest; within the scope of this research the shared field of interest was the blended learning approach for teaching STEM-related subjects. Within the ambits of CoP, members of the community engage in shared activities and discussions. Within the spheres of this research were the interactive workshops in which the teachers participated. Members of a CoP are practitioners; within this research, the members of this community were teachers of STEM-related subjects. Thus, this theoretical framework provided the framing for exploring the blended learning approach (Smith et al., 2017) and was adequate to frame this research which focused on exploring mathematics and technology teachers' perceptions of using the blended learning approach for STEM-related subjects within the 4IR.

Research Focus and Research Question

In the scope of this research, as society embraces the 4IR, we need to explore if STEM teachers are adequately prepared to use technology-enabled pedagogy. The research aim was to explore teachers' perceptions of using the blended learning approach for STEM-related subjects. Two interactive workshops on exploring the blended learning approach for STEM-related subjects within the 4IR were conducted with participants. Subsequently, semi-structured interviews were conducted with the participants.

The purpose of the interactive workshops and the interviews was to respond to the main research question:

What are mathematics and technology teachers' perceptions of using the blended learning approach for STEM-related subjects within the 4IR?

Research Methodology

General Background

This research explored teachers' perceptions of using the blended learning approach for STEM-related subjects. For this reason, an interpretive paradigm was adopted to carry out the research which employed a qualitative case study design. Qualitative data were collected using reliable and valid research instruments. Researchers using the interpretive paradigm, use qualitative approaches to explore practices, knowledge and perceptions of people to reveal the reality of their data (Thanh & Thanh, 2015).

The research was conducted at one university in the first semester (15 weeks) of the 2019 academic year. The research incorporated two interactive workshops and one semi-structured face to face individual interview with postgraduate STEM students who were also teaching STEM-related subjects at secondary/high schools. This case study comprised of a descriptive and probing analysis of the perceptions of the participants who taught STEM-related subjects in secondary/high schools. The research was framed using the theory of Communities of Practice.

Population and Sampling

The population for the research were 139 Bachelor of Education postgraduate STEM education students registered at one participating university. These participants were registered for the Honors, Masters or Doctoral degree in Education. Every student that was enrolled for a postgraduate degree in STEM education at the participating university was offered the chance to participate in this research. Participation in the data generation process was voluntary (Šorgo & Špernjak, 2020). Thus, participants who did not volunteer to participate were omitted in the selection for the pilot and main research. All participants were teaching mathematics and technology at secondary/high school level; these participants were the cases under study.

The research was a small scale in-depth qualitative study, and a total of 47 postgraduate students agreed to participate in the research. Besides, the number of participants who participated in the research represented

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approximately one-third of the total population. Therefore, the sample size was sufficient to represent the total population. A random sample of ten participants was selected to participate in the pilot research. Data were generated through two interactive workshops and face to face individual semi-structured interviews.

Pilot Research

Pilot research was conducted to ensure the dependability and validity of the research process and the research instruments. Through this process, the research instruments were modified. For example, through the pilot research, it was observed that there was an error during the first workshop presentation, which led to an adjustment to this presentation. Also, some participants in the pilot research were uncertain of what was required in specific questions on the interview schedule.

Subsequently, questions were rephrased to eliminate ambiguity and to ensure that each item was apparent. Moreover, the language used during the workshops and on the interview schedule was precise and straight forward to increase the reliability.

Interactive Workshops

Two workshops for the main research were conducted with 37 participants. These workshops were facilitated by the researchers and held on two Saturdays during the first semester of the 2019 academic year. The workshops lasted approximately 5 hours per Saturday with two breaks (one 30- minute tea break and a 1-hour lunch break) scheduled in between the workshop activities. The workshops were focused on exploring the blended learning approach for STEM-related subjects within the 4IR. Activities were based on teaching and learning financial mathematics and teaching and learning hydraulics and pneumatics.

The learning outcomes for the mathematics activities included the students' ability to solve problems in contexts that may be used to build awareness of other learning areas concerning profit and loss, budgets, hire purchase, exchange rates and banking. The learning outcomes for the technology activities included the students' ability to apply technological processes and skills ethically and sensibly using suitable information and communication technologies to demonstrate an understanding of the link between science, technology, society and the environment.

At each workshop, participants were provided with PowerPoint presentations focusing on teaching notes, examples of lesson plans, examples of assessments and demonstrations of how technology-enabled pedagogy could be embedded effectively within STEM-related classrooms. Subsequently, participants were invited to participate in an individual interview towards the end of the 2019 academic year. This meant that each participant would have the opportunity of reflecting on what they had learned from the workshops. Their learnings would possibly advance their practice and thereby promote their professional development.

Semi-Structured Interviews

Although 37 teachers participated in the two interactive workshops, due to work, study, family or other commitments, only 23 participants were available to be interviewed. The number of participants who participated in the interviews represented approximately 62% of the total population who participated in the workshops. Therefore, the sample size for the interviews was sufficient to represent the total population. The semi-structured face to face individual interview was audiotaped and then transcribed. The reason for selecting semi-structured interviews was so that responses for each interview item could be probed further to obtain clarity of responses. The reason for choosing face to face individual interviews was that this type of interview minimized non-response and maximized the quality of the data collected. Also, face to face one-on-one interviews appeared to make the participants feel at ease; it seemed as if the personal contact with the researcher was a source of motivation for the participants. Participants could also openly ask for questions to be explained in further detail. This type of interview also enabled the researchers to ask for clarification of responses.

The interviews were semi-structured and focused on the following key questions:

- What were the participant's perceptions of the blended learning approach?
- What were examples of blending learning used by each participant in their classroom?
- What were the strengths/challenges of using the blended learning approach within the classroom context?

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- Were the two workshops of any benefit to the participants while planning on integrating blended learning within lessons?

Since the interviews were semi-structured, further questions were included as each interview progressed, to probe each participant's responses. Transcripts were sent to participants to ensure the accuracy and validity of what was stated during the interview. The purpose of the interview was to gain more clarity on each participant's perception of the blended learning approach for STEM-related subjects within the 4IR. The interviews were conducted at the participating university at a convenient time for each participant.

Data Analysis

Data analysis which encompassed coding and categorizing of themes was based on the conceptual framework of the research, i.e. Communities of Practice. The data analysis process resulted in generating codes for describing participants' responses to the interview questions. All data generated were analyzed qualitatively, and all transcribed interview data were read and reread line by line in-order for the researchers to become familiar with the data. After the transcriptions of each interview were completed, the interview data were inspected, and data were segmented into meaningful codes. The purpose of this type of coding was to reveal teachers' perceptions of using the blended learning approach for STEM-related subjects within the 4IR.

These codes were carefully reviewed and captured as themes. Thus, thematic coding was inductively used to generate themes. The themes that were identified provided a clear picture of teachers' perceptions on the use of the blended learning approach for STEM-related subjects within the 4IR. Four main themes were identified from the qualitative content analysis of the interview transcripts. Teachers' perceptions on the use of the blended learning approach were: it is impeded by the lack of technology-based tools; it is hampered by limited teacher professional development; it offered the use of virtual hours for consultation and feedback within STEM-related milieus, it increased engagement and collaboration within STEM-related milieus.

Ethical Issues

Gatekeeper access and ethical clearance were obtained from the research office of the participating university. Participants were provided with an information sheet outlining the purpose and process of the research. This informed consent sheet also included the participants' right to withdraw from the research. Also, the participants provided permission for the audiotaping of the individual face to face semi-structured interviews.

Furthermore, the anonymity and confidentiality of participants were assured by using codes. Numbers were assigned in the order that each participant was interviewed. For example, Participant 5 refers to a participant that was interviewed fifth, and Participant 21 refers to a participant that was number 21 on the interview timetable.

Research Results

While in general, the participating teachers valued the use of the blended learning approach within STEM classrooms, they did indicate that they had uncertainties and experienced challenges when trying to imitate what they had learnt during the two interactive workshops. The participants' responses are described in the results that follow.

The Blended Learning Approach is Impeded by the Lack of Technology-Based Tools

Based on the interview responses, it was apparent that the participants had tried to replicate the demonstrations and their experiences from the workshop. Some of the participants had challenges due to the shortage of technology-based tools within their educational milieus. This view is supported by excerpts from the interview transcripts that follow.

> **Participant 1:** …I want to try blended learning in my technology class…we can share ideas and talk about creating practical examples of pulleys…they [the learners][1] may not be able to view the video about mechanic control systems to prepare…my learners come from different backgrounds and may not have access to the internet at home…

[1] Words in square brackets within the transcripts have been added by the researcher to support the reader's understanding.

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Participant 7: …it looks so interesting to try…we can discuss these examples for financial math in class…I don't have access … PowerPoints and videos…
Participant 10: …this will help my class…we can use realistic examples of hydraulics in everyday life…they [the learners] will not be able to view the videos to prepare for the class…they don't have the necessary tools…
Participant 13: …I only have the computer at school…do not have my computer…it will be difficult to try blended learning…
Participant 21: …we have load shedding[2] quite often…my class may not have electricity to view the lessons online…
Participant 23: …this would be an excellent idea for my class…I do not have access to these videos … I have limited internet access…even worse for my class…they need to go to the municipal library or internet café to get access… this is not something we can try daily…

It is evident from the preceding transcripts that the participants embraced the notions of CoP by focusing on sharing ideas and discussing realistic examples. However, the lack of material resources hampered teachers while they attempted to incorporate aspects of the blended learning approach within their classrooms. The preceding transcript excerpts indicate that teachers embraced the Fourth Industrial Revolution and integrated the notions of blended learning within their STEM classrooms.

However, the limited access to the internet and technology-based resources affected the teachers' capabilities and motivation for integrating technology-based learning within their classrooms. Role-players within education sectors need to collaborate to ensure that classrooms related to STEM subjects are sufficiently equipped with the essential resources necessary to embrace the 4IR.

The Blended Learning Approach is Hampered by Limited Teacher Professional Development

To successfully create a blended learning environment, teachers need to have the necessary skills and knowledge. This implies that teachers require adequate professional development to use technology-based resources effectively. In this research, some participants indicated that they lacked sufficient pedagogical content knowledge to use technology-based resources effectively. This notion is exemplified in the transcript excerpts that follow.

Participant 2: …I can see my myself trying blended learning…I need to learn how to…I can use PowerPoints…the podcasts and selecting and uploading videos is a bit of a problem…
Participant 4: …it seems easy enough…but I don't think I know how to record my voice for each slide in the PowerPoint…I also do not know how to create the videos…
Participant 6: …this is so useful…I know my class will understand since they work with apps…but I need more training with this…
Participant 9: …I made contact with other teachers from the workshop…discussed ways of using blended learning… the department needs to provide us with more workshops…
Participant 13: …I only have access to the school computer…need training on how to create these podcasts and videos…
Participant 15: …I taught my lesson online, but I had a problem with the large size of the files…did not know how to make the recordings smaller…I need help with things like that…

As is evident, teacher professional development workshops focused on the effective use of technology-based resources for teaching are crucial. If teachers participated in teacher professional development workshops related to teaching STEM subjects within the domains of blended learning, this would assist with embracing the notions of the 4IR.

[2] Load shedding refers to the interruption of electricity supply to avoid excessive overload. Load shedding is active when there is a high demand for electricity. Load shedding is a planned interruption in electricity supply by the Department of Electricity in South Africa. All consumers are informed in advance of load shedding times within their areas through the use of a comprehensive schedule.

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The Blended Learning Approach Offered the use of Virtual Hours for Consultation and Feedback within STEM-Related Milieus

The participating teachers indicated that often they did not have enough time in class to complete meaningful discussions and clarify concepts. Consequently, the use of the blended learning environment provided them with another way of completing discussions, explaining concepts and submitting much-needed feedback, virtually. The participants were of the view that the blended learning approach allowed them to transform their identity as they were shifting how they taught and how they viewed teaching. These notions are exhibited in the transcript excerpts that follow.

> **Participant 1:** …they [the learners] can ask questions at any time…I can provide feedback at any time…this is something that can work…but my entire class can't participate because they don't all have access to the internet…
> **Participant 4:** …it seems beneficial, especially for my shy learners…they now can chat with me without having to ask questions in front of the rest of the class…they can do this at any time…but we are all learning how to use the different technology…I am not an expert…I try my best…I find myself changing how I do things…
> **Participant 14:** …this is exciting…the blending learning allows my class to try the exercise on Profit and Loss at home…then we can discuss online or in class…I feel that I am different as a teacher…I am not so stressed since there seems to be more time for us to discuss…the learners become more attentive…
> **Participant 17:** …we work online at any time…the class has more time to think about and discuss their problems regarding the section on gears…especially for those who are reserved and don't like speaking in class…this provides a good opportunity to clarify and interact with each other…
> **Participant 20:** …I feel as if the blended learning brings something new for me as a teacher…I am changing how I teach…I am enjoying it…I am enjoying consulting with my students online…I am more like a guide…the class is more involved…
> **Participant 21:** …this is a good idea…it gives the class more time and more ways to solve problems on finance…discussing problems online seems better for the class, especially when they are shy in the class…but issues with electricity an internet causes problems…
> **Participant 22:** …sometime we run out of time in class…blended learning allows me to share with my class important information online…they can then look at this at their own time and we can talk about problems virtually…this is a good idea if we all have the necessary tools…the class becomes more lively in this process…

Some students are often reluctant to ask questions during lesson time, especially if they think their problem is not important. If the teacher allowed students to engage with the teacher and class virtually, this would alleviate some of these issues. The blended learning environment could be used for organizing virtual consultation hours. Students could be invited to discuss with the teacher during virtual consultation times. Based on the preceding transcripts, it was evident that students welcomed the opportunity to discuss queries virtually, and teachers ensured that misunderstandings were addressed swiftly.

The use of the blended learning approach created a transformation in traditional teaching and learning, which brought about a change in the identity of both the teacher and students. Within the domains of CoP, the notion of identity is valued and is fixated on how learning transformed who the individuals are. In this research it was evident that the blended learning approach changed the status of both the teachers and students with the STEM classrooms; teachers became the facilitators, and the learners became more active within the learning process.

The Blended Learning Approach Increased Engagement and Collaboration within STEM-Related Milieus

The participants indicated that the blended learning approach increased engagement and collaboration within STEM-related classrooms. The participants employed the use of a blended learning approach within their classes after being exposed to this type of strategy during the workshops. They combined the use of technology and the traditional 'chalk and talk' method within their STEM classrooms. Based on the results of this research, this type of approach exhibited interaction and collaboration within the STEM classroom. This is supported by the transcript excerpts that follow.

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Participant 1: …I know many of my class don't have access to the internet at home…class time we started using a WhatsApp group to discuss some ideas around our topic on hydraulics…this created interaction, discussion and they [the learners] were working together and helping each other…the school has internet so the class could download some information to look at later when they were at home…

Participant 2: …it seems that my class is better at using technology…helped me to download information…this created a change in the roles…this created teamwork and discussion…the class were more involved…creating a PowerPoint worked well, to sum up, all the important ideas…

Participant 8: …I found that blended learning creates a buzz of activity and discussion in the class…we were talking about Finances and Small Businesses. They just came alive…they were very interested in a short clip from a Netflix[3] video I shared with them regarding financial swindles…

Participant 10: …I found this works in my technology class…view videos on making pulleys etc. and then we can discuss the process in class…they are more talkative since they know what is being taught…it is relevant and real-world examples are used…

Participant 11: …my class were absorbed in the lesson…they could discuss more because they viewed the video beforehand…the asked refreshing questions…they had more time to think about the content being taught…

Participant 19: …I moved from the board to the video…it was exciting…they [the learners] wanted to know more…this was a good idea…

To achieve engagement, the blended approach encompassed a variety of resources. Videos, PowerPoint presentations and visually enriched demonstrations were integrated within the blended learning environment to include learners and to ensure that content was comprehensible.

As was evident, through the use of the blended learning approach, the participants made the learners responsible for their learning. This notion was supported by the use of WhatsApp before the lesson commenced, as was evident in the response provided by Participant 1.

Discussion

The qualitative results provide evidence on the participants' perceptions of using the blended learning approach for STEM-related subjects. The participants indicated that the blended learning approach was impeded by the lack of technology-based tools. The participants could not repeat all activities that were discussed during the workshop since they did not have access to all the necessary technology-based resources. However, they embraced the notions of CoP by focusing on sharing ideas and discussing realistic examples. Similarly, Evans et al., (2014) proposed using conversations for practical learning activities which provide a clear indication of how technology may be used for creating shared knowledge and resources. In this research, it was evident that limited access to the internet and technology-based resources also influenced the participants' capabilities and motivation for integrating technology-based learning within their classrooms (Klopfer et al., 2006).

The participants indicated that the blended learning approach was hampered by limited teacher professional development. This result is supported by Ertmer and Ottenbreit-Leftwich (2012). They have maintained that to successfully create a blended learning environment, teachers require adequate professional development to use technology-based resources effectively. As is evident in this research, there is a need for teacher professional development workshops focusing on the effective use of technology-based resources for teaching (Dlamini & Mbatha, 2018). While blended learning may be used to transform teaching and learning activities (Hains-Wesson & Tytler, 2015), teachers require professional development to become innovative and at ease with the use of technology to integrate blended learning within their classroom contexts (Scott & Scott, 2010). Thus, teachers need to organize a CoP (Wenger & Wenger-Trayner, 2015), so that they may collaborate around ideas related to the teaching of STEM-related subjects. Teachers are required to network with each other to learn together. Thus, if teachers participate in teacher professional development workshops related to teaching STEM subjects within the domains of blended learning, this would assist in embracing the notions of the 4IR.

Moreover, the participants indicated that the blended learning approach offered the use of virtual hours

[3] Netflix allows individuals who pay for this streaming service to watch movies, television shows and documentaries using devices connected to the internet.

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for consultation and feedback within STEM-related classrooms. Similarly, research (Jeffrey et al., 2014) have maintained that blended learning may be defined as an approach to teaching that disregards time, place, and contextual barriers while empowering robust collaborations between teachers and students. Additionally, within the domains of CoP, the notion of identity is valued. It is fixated on how learning changes who we are, since individuals participating within a community, attain new knowledge, and concurrently their identities, transform (Wenger, 1998b; Wenger & Wenger-Trayner, 2015).

Furthermore, the participants indicated that the blended learning approach encouraged engagement through the use of various technology-based resources. This result resonates with research (Jeffrey et al., 2014), which maintained that teachers need to be encouraged to reflect on and restructure their lessons so that students are provided with diverse learning experiences and resources. As was evident in this research, through the use of the blended learning approach, the teachers encouraged learners to become responsible for their learning. Similarly, linking learners and resources online does not necessarily take place in the classroom; this is ubiquitous due to our access to the internet (Bell, 2011). Within the ambits of CoP, collaboration is supported whereby student learning is enriched by sharing and cooperation (Wenger, 1998a; Wenger & Wenger-Trayner, 2015). As was evident, in this research, through the blended learning approach, the learners collaborated and discussed solutions in the STEM classrooms while the teacher facilitated.

Conclusions

This research aimed to explore teachers' perceptions of the blended learning approach for STEM-related subjects within the Fourth Industrial Revolution. This qualitative, interpretive research was conducted at one university in KwaZulu-Natal, South Africa. Participants were invited to two interactive workshops and were consequently interviewed. Four main themes were identified from the qualitative analysis of the interview transcripts. Teachers' perceptions on the use of the blended learning approach are: it is impeded by the lack of technology-based tools; it is hampered by limited teacher professional development; it offers the use of virtual hours for consultation and feedback within STEM-related milieus, it increases engagement and collaboration within STEM-related milieus.

This research has provided interesting perceptions regarding the blended learning approach for STEM-related subjects within the 4IR. Moreover, based on the results of this research it is apparent that within the contemporary STEM classroom, as technology becomes more available and if Communities of Practice are embraced as a useful framework, teachers will seek to engage in supportive pedagogy to amplify the benefits to student learning. However, for the successful integration of blended learning within the contemporary STEM classroom, there is a need for technology-based resources and for teachers to be involved in professional development workshops focusing on how to enhance student learning within the blended learning environment. These professional development workshops would be of benefit to teachers of STEM-related subjects globally as we embrace the Fourth Industrial Revolution.

Further studies on a larger scale for exploring teachers' perceptions of using the blended learning approach for STEM-related subjects are needed. Opportunities for future research could include qualitative studies conducted at several universities within different provinces in South Africa. Similar studies could also be done at universities internationally. Large scale data may provide greater reliability and opportunities for further qualitative analysis and interpretation. Further quantitative studies could also be conducted nationally and globally to explore teachers' perceptions of using the blended learning approach when teaching STEM-related subjects. This would be beneficial for increasing the knowledge base in the field within South Africa and globally.

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