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PRE-SERVICE SCIENCE TEACHERS' EXPERIENCES OF HOME-BASED PRACTICAL WORK UNDER EMERGENCY REMOTE TEACHING

Tamirirofa Chirikure

Abstract. *Practical work is ubiquitous in science education, but its enactment is challenging in remote teaching contexts. The situation was exacerbated due to a moratorium on contact classes induced by the COVID-19 pandemic that necessitated strict health protocols. Home-based practical work (HBPW) became a significant option as academic institutions shifted to emergency remote teaching. The question is whether HBPW provides equivalent learning experiences in comparison to laboratory-based practical work (LBPW). This research therefore explored pre-service science teachers' experiences of HBPW implemented at a particular South African university. Eighty-four preservice science teachers, who engaged in HBPW in a chemistry module, were purposively selected as the participants. The data were generated through individual reflections at the end of the semester. An adaption of the equivalence theory was ideal in analysing and interpreting the results. Results show that HBPW was flexible, empowering, contextualised, and enhanced active learning. New forms of interaction emerged in the absence of physical student-teacher and student-student interactions. Concerns over its ability to develop practical skills are expressed. Recommendations are made with a view to optimising HBPW.*

Keywords: *emergency remote teaching, home-based practical work, laboratory-based practical work, pre-service science teachers, student-teacher interactions*

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Introduction

Chemistry curricula around the world place significant emphasis on a practical work-based teaching approach to develop conceptual and procedural knowledge as well as scientific reasoning. In this regard, chemical educators regard laboratories as the place to do chemistry (Reid & Shah, 2007; Seery, 2020) in their mission to pass on relevant skills to the next generation of the disciples of the subject. The hazardous nature of many chemicals makes it plausible to restrict chemistry practical activities to a specially built physical space with safety measures in place. This often raises concerns over the contextualisation of chemistry content and increased calls for alternative ways of mediating the subject (McDonnell et al., 2007). The emergence of the COVID-19 pandemic in late 2019 led to the cessation of contact lectures (Schultz et al., 2020) and practical work was the major casualty. The consequences of the loss of practical work in chemistry courses was highlighted by Reid and Shah (2007, p. 174) who argued that students may continue to pass science courses but they would not experience the "feel for chemistry, for chemicals, for instrumentation", or the scientific method. As a result, students will view chemistry as extremely abstract and theoretical, which may lead to negative perceptions of chemistry (Basu & Barton, 2007).

Reduced practical work or its complete loss would be significant in science teacher training where doing practical work goes beyond acquiring conceptual and procedural knowledge to include learning of how to teach through practical demonstrations, experimentation, and science investigations. To satisfy the practical work component, home-based practical work (HBPW) emerged as a viable alternative when contact educational institutions adopted emergency remote teaching (ERT) using an assortment of online platforms (Nguyen & Keuseman, 2020; Schultz et al., 2020). ERT is a provisional shift of instructional delivery mode characterised by wholly remote teaching solutions in place of contact instruction as a temporary measure until the causative crisis has subsided (Hodges et al., 2020). Some scholars prefer the term "kitchen chemistry" (Jacobsen, 2011; Lyall & Patti, 2010; Schultz et al., 2020) but HBPW is preferred in this research because diverse home contexts imply that the practical work may not necessarily be done in a kitchen. Infusing HBPW in chemical education promotes active learning as students design and carry out practical activities using materials found in their home environments (Lyall & Patti, 2010). Such an approach leads to fewer gaps in the skills

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set acquired by students as they autonomously engage in practical work to develop the requisite competences.

Research on HBPW has focused primarily on the development and evaluation of blended approaches (Brewer et al., 2013), comparing student performance with those where laboratory-based practical work (LBPW) is used (Casanova et al., 2006; Kennepohl, 2007, 2010; Neves et al., 2017; Nja et al., 2020), and as a methodological approach to reinforce the scientific method in real world contexts (Nguyen & Keuseman, 2020). Students' experiences, particularly preservice science teachers (PSTs), remain under researched. As future teachers, PSTs' experiences of HBPW influence their epistemological beliefs of teaching and doing science. The loss of physical interactions, reminiscent of LBPW, leads to different learning experiences and possibly a diversity of achieved learning outcomes hence, it was important to understand how PSTs experienced HBPW.

Literature Review

There is increasing research on HBPW, particularly kitchen chemistry, in relation to food science courses and other chemistry-related courses in higher education (Al-Soufi et al., 2020; Lyall & Patti, 2010; Nguyen & Keuseman, 2020; Schultz et al., 2020). This is a consequence of the emergence of HBPW as a stopgap measure to enact practical work in the era of COVID-19 where contact sessions are not an option, especially with large classes and small laboratories.

The aims of HBPW are varied. These include reinforcing conceptual understanding through practical work in context, developing basic and integrated science process skills in students through equivalent off-campus experiments, and inspiring students to study chemistry (Boschmann, 2003; Casanova et al., 2006). This includes building linkages between chemistry content and everyday life, making chemistry-learning experiences meaningful to students, and putting emphasis on chemistry knowledge construction through hands-on activities where students experience doing chemistry (King, 2012). To achieve these aims, real-life contexts should be used as the foundation for chemistry education. Consequently, school chemistry and real-life contexts must feed into each other for students to appreciate the significance of chemistry in their individual and communal lives (Kitzmann & Otto, 2008; Nuora & Välisaari, 2020). Thus, learning of chemistry content should be intertwined with life outside school settings in order to develop students' ability to apply the related skills and knowledge in real-life situations. When chemistry becomes visible in students' everyday lives, they become more motivated to learn the subject (Ivanitskaya et al., 2002).

When students engage in HBPW, they have an opportunity to design and carry out their own experiments in their home contexts. This provides opportunities for authentic chemistry learning through scientifically meaningful experiences (Tan et al., 2019). HBPW strengthens an autonomous learning culture that enhances self-directed learning (Neves et al., 2017). In addition, doing practical chemistry work in unconventional spaces makes chemistry more accessible to every student (Jacobsen, 2011; Kennepohl, 2007)2011; Kennepohl, 2007. It also provides a platform for transdisciplinary knowledge integration between home economics and chemistry (Ivanitskaya et al., 2002). According to Tan et al. (2019, p. 39),

> …students get to see a direct application of concepts of chemical composition and molecular structure …. and their relevance to everyday life. They gain an understanding of cause and effect, seeing the effect of independent variables on dependent variables ….. They learn how to evaluate questions on data measurement and data analysis during experiments…. They also experience the development of new and innovative procedures based on observation and reasoning. These forms of learning can serve to increase career awareness….

Chemical educators have an obligation to make chemistry meaningful to students by engaging them in activities that enable them to experience the subject as pertinent to their daily lives (Gilbert, 2006; Nuora & Välisaari, 2020). This implies the adoption and practice of context-based chemistry education reinforced by HBPW. Such an approach to mediating chemistry content may allow students to create rational and coherent conceptual maps of the content they learn. By using the home kitchen as a "chemistry laboratory", it is possible to achieve the intended learning outcomes regarding procedural knowledge and helping students to see the relevance of chemistry in everyday life (McDonnell et al., 2007). In addition, students assume different views of their food, household cleaners and utensils as they see possibilities for designing their own experiments (Jacobsen, 2011).

According to Carnduff and Reid (2003), there are three broad areas that define the need for practical chemistry work in higher education. First, *practical skills*, which encompass occupational health, procedural knowledge, and

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manipulative skills. Second, *transferable skills*, which include process skills, teamwork, organisation, time management, and information retrieval. Third, *intellectual stimulation*, which involves making connections with the real world and the affective domain. Whether traditional or non-traditional laboratory settings are used, chemical educators should carefully decide and outline the skills that need to be developed for each course. When there is a shift to non-traditional laboratories such as the kitchen, it is crucial to ensure that students have learning experiences similar to those realised in school laboratories, albeit using their own imagination to design experiments using varied materials found in their home pantries.

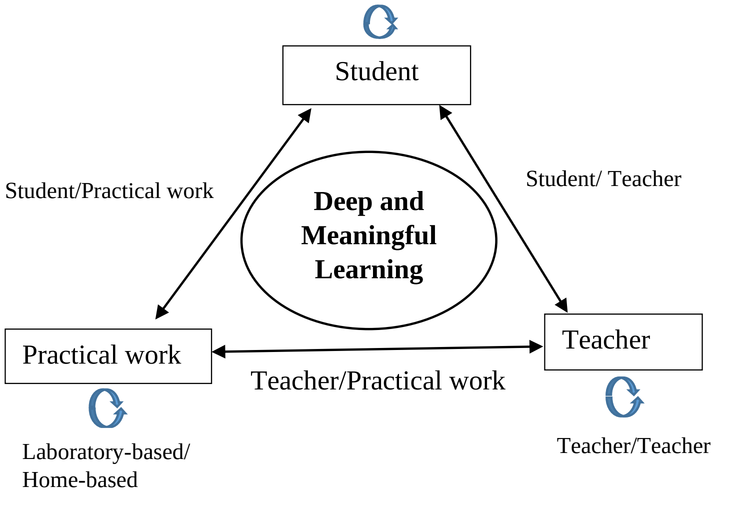
Researchers have also highlighted other positives proffered by enacting HBPW. Where large classes are involved, HBPW eases timetabling pressures, advances active learning (Schultz et al., 2020), and curbs the financial burden of running practical work on campus (Nguyen & Keuseman, 2020). In some instances, HBPW has been found to heighten students' motivation as it enabled them to continue with their studies in lockdown settings without compromising the achievement of learning outcomes when compared to conventional LBPW (Al-Soufi et al., 2020). It is also ideal in contexts of resource deprivation (Ashworth, 2018), especially in developing countries that include the context in which this research was accomplished.

HBPW has its critics. Some scholars have argued that while it may theoretically provide the same learning opportunities, it does not necessarily offer the same learning experiences (Casanova et al., 2006) thereby raising questions about rigour and authenticity (Brewer et al., 2013). Due to restricted physical interaction, students suffer from seclusion due to limited student-teacher interactions which would provide guidance and quality assurance (Kennepohl, 2007). HBPW is also viewed as inadequate for students intending to pursue further studies in chemistry (Lyall & Patti, 2010) but is largely suitable for introductory chemistry courses which can be executed without specialised equipment (Nguyen & Keuseman, 2020). Even in such courses, well-designed experiments with a clear purpose are key to the success of this teaching-learning strategy. The added complexity of training science teachers means relying on autonomous practical activities could be a less appealing option, given curriculum imperatives emphasizing uniformity of learning outcomes and comparability of teaching degree programmes across universities. An emphasis on quality and rigour in HBPW is therefore critical for its acceptance as a viable alternative (Brewer et al., 2013). In pursuit of rigour and uniformity of learning experiences, home-laboratory kits have been developed for distance learning courses in some countries (Brewer et al., 2013) but the abruptness of lockdown restrictions did not give a chance to adopt this option.

The Equivalency Theorem

The framework (Figure 1) used in this research was inspired by the work of Anderson and Garrison (1998), who proposed the modes of interaction for distance education framework, and Anderson (2003), who developed the equivalency theorem. The assumption was that ERT is similar in many aspects to distance education.

Figure 1
Modes of Interaction for Practical Work [adapted from Anderson (2003)]



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The diversity of instructional media and sources of information entail that no single strategy is superior in all aspects to the others. Arguably, learning outcomes can be attained by using any medium or strategy to a comparable degree. Effective, deep, and meaningful learning can be attained irrespective of the teaching strategy or medium used. In this regard, practical skills can be developed through either LBPW or HBPW, granted that similar activities are planned, assigned, and performed.

Social interactions between students serve to enhance meaningful active learning. More capable peers assist others to navigate to the zone of proximal development (Fani & Ghaemi, 2011). In practical work, students can also learn practical skills by observing peers demonstrating the use of equipment, taking and recording measurements, and processing data among others. Students also interact with the content of the practical activities individually and collectively.

Teacher-student interactions are also pivotal in achieving the intended learning outcomes. Orientation towards practical tasks, demonstrations, monitoring and giving technical assistance during activities, and giving feedback constitute interactions that determine the effectiveness of the activities. Under LBPW, students benefit from physical interactions and instant feedback. When students do HBPW, they rely on manuals and recorded demonstrations for orientation. The emergence of social media means that technical assistance can be offered in real time through Zoom meetings, Skype conferencing, WhatsApp video calling, and other platforms. This implies that, in terms of interactions, the boundaries between LBPW and HBPW are blurring.

Both teachers (lecturers) and students interact with the content of the prescribed practical activities. Teacher-practical work interactions start with designing or choosing the activities to be done by the students. The interactions often extend to preparing and performing demonstrations for students to see how they should do it and what they are expected to achieve. Students on their part interact with practical activities when they perform them in the school laboratory or at home. The interactions may also involve watching a demonstration by the teacher, a peer, or on the internet with a view to acquiring procedural knowledge.

The different forms of interactions can each contribute to the realisation of deep meaningful learning through active engagement with practical work individually and with others. Anderson (2003, p. 4) proposed that:

> Deep and meaningful formal learning is supported as long as one of the three forms of interaction (student–teacher; student-student; student-content) is at a high level. The other two may be offered at minimal levels, or even eliminated, without degrading the educational experience.

Anderson (2003) further asserted that the manifestation of more than one form of interaction at a high level will, in all probability, lead to more substantial learning experiences. Pursuing deep meaningful learning by providing many modes of interaction should be counterbalanced with the financial and time implications. In the COVID-19 era, health protocols have also become a factor.

The equivalency theory informed the data reduction from the extensive reflections, analysis, and interpretation of the results in order to respond to the guiding research question.

Research Question

The guiding question was: What are the students' experiences of HBPW? The experiences covered the participants' perceptions of HBPW, its strength and weaknesses as well as the challenges they faced in designing and performing the practical activities.

Research Methodology

General Background

An interpretive qualitative approach and case study design were adopted (Creswell, 2015; Creswell & Creswell, 2018). Qualitative data were generated through the participants' individual reflections on the HBPW practical activities. The strength of qualitative inquiry lies in deriving meaning from the participants' lived experiences (Mertens, 2020). Such experiences provide invaluable insights, which could inform future practice (Denzin & Lincoln, 2018; Yin, 2016).

The research was conducted at the School of Education at a South African university which offers a Bachelor

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of Education degree in physical sciences education. The period of research spanned over one semester during which the participants were doing a physical chemistry module.

Participants

The participants were a purposive sample of 84 second year physical sciences pre-service teachers (PSTs) who were doing a chemistry module. They did HBPW at a time when health protocols induced by the COVID-19 pandemic made it impossible to do LBPW. The PSTs were therefore engaging in their studies while based at their homes in affluent suburban areas (15), urban townships (39) or rural areas (30). The varied home contexts defined the socio-economic standing of the students. This meant that uniformity in the materials used to perform the HBPW could not be guaranteed.

While the HBPW was graded and contributed towards the module marks, the reflective journals were merely produced for the purposes of this study. This ensured that none of the participants were prejudiced if they chose not to participate. All 84 PSTs consented to taking part in the study and submitted their reflections.

Data Generation

The PSTs were assigned to design and carry out six experiments at home. No home-laboratory kits were provided to the PSTs. They had to use materials available in their home contexts to carry out their experiments. In principle, the experiments were identical to the ones used in previous years as LBPW. However, each PST had the latitude to decide the equipment and substances to use depending on availability in their home environment. The topics and HBPW activities are shown in Table 1.

The PSTs video-recorded themselves doing each of the experiments and submitted the videos for assessment including the experimental designs and results. At the end of the semester the PSTs were asked to produce a minimum of an A4 typed page reflection of their experiences of doing HBPW. The prompts provided were for the participants to include reflections on their interactions, perceptions, strengths, weaknesses, and how they sourced the materials. Only the reflections were used as data sources for this study. Reflections have been used by other researchers investigating related phenomena to complement other data collection methods (Brewer et al., 2013). The number of reflections (84) led to data saturation, so they were deemed adequate as a data source.

Table 1
Topics and Activities for HBPW

Chemistry Topic	Practical activity
Energy changes	1. Investigating the enthalpy change of combustion. 2. Determining the enthalpy change of solution. 3. Determining the enthalpy change of reaction.
Reaction kinetics	4. Investigating the effect of concentration on the rate of reaction. 5. Investigating the effect of a catalyst on the rate of reaction. 6. Investigating the rate of reaction.

Data Analysis

The textual data contained in the reflections was subjected to thematic analysis where open coding preceded axial coding (Cohen et al., 2018). By examining, comparing, conceptualising, and categorizing data, the initial codes were crystallised into emergent themes regarding the PSTs' experiences of HBPW. To eliminate redundancy of themes, two critical friends assisted in validating the coding. A Zoom meeting was organised to give feedback to the PSTs regarding the salient themes. Sixty-three of the 84 participants joined the meeting and there were no objections to the researcher's interpretation of the data.

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Research Results

The PSTs' reflections revealed a range of themes such as the emergence of new forms of interactions, reinforcement of active learning, empowerment, increased interest, autonomy, and flexibility of HBPW. These positive outcomes are articulated in the sections that follow including adverse experiences with a view to presenting a balanced account.

New Forms of Virtual and Physical Interaction Emerged as Vital Support Structures

The absence of LBPW and enactment of HBPW removed student-lecturer, student-demonstrator, and student-student physical interactions. The exploitation of social media, particularly Zoom and WhatsApp, for virtual synchronous interactions by all the participants blurred the physical distance between the parties resulting in students feeling less isolated, even though they were working at home. Eunice recounted how virtual interactions made a difference in her work:

> At first, I was worried about how I would manage without the lecturer and demonstrators assisting me physically. My fears were allayed by their accessibility on WhatsApp and Zoom each time I needed help. Recording the video chats helped because I could always replay them if I forgot something.

In the absence of traditional physical interactions reminiscent of LBPW, student-family and student-community interactions emerged to fill the gap. Sixty-one of the 84 (73%) participants reported that family members and/or neighbours were involved in performing and video recording the experiments. Raul was very excited to get his family involved and explain to them what each experiment was about:

> My mother was so excited to see me do experiments in our kitchen. She had been worried that the lockdown would hinder my academic progress. My four siblings wouldn't let me do my experiments alone. They were eager to get involved as they are studying science in high school. I would explain to them what the experiment was about, and this helped me to in many ways. I wanted to present myself as knowledgeable so, I made sure that I prepared well before doing each experiment.

Siya, like 37 others (38%), went further to involve high school learners in his neighbourhood:

> I leave in a complex with at least six high school learners as my neighbours. When I told them that I was doing practical work for one of my modules in the house, they asked if they could come to watch me do it. Some told me they were inspired to study chemistry at university after seeing one of their own doing it. In the end I saw an opportunity to assist them in their studies by doing other experiments to help them learn while under lockdown. Working with these high school learners helped me too. I prepared thoroughly which helped me to understand the chemistry better. It also gave me an opportunity to practice teaching.

Apparently, HBPW had the unplanned but welcome benefit of enhancing community scientific literacy and inspiring students from the students' communities to want to study science. By making learning visible at home and community level, young learners were inspired to study science beyond high school level.

There were challenges with communication in some instances. Twelve PSTs (14%) lamented the limited interactions with the lecturer, demonstrators, and more capable colleagues. The use of social media was not always synchronous. They could not get assistance at the exact moment they were doing their experiments and needed help. In her reflection, Nelly wrote:

> *When I was doing the experiment on the effect of concentration on the rate of reaction, I wanted help on how I could improve the accuracy of my measurements using the equipment I had. My network connectivity was poor so, I couldn't reach my lecturer or demonstrator. Two of my colleagues told me they had the same issues too.*

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HPBW Reinforced Active Learning

Most of the PSTs (71%) reported thinking deeply about what they were doing at every stage from designing the experiments to data analysis and interpretation. Rachael said:

> It made me THINK about what I was doing and going to do for the first time like a real chemist. I gained foresight to know what data to collect before doing experiments, so I don't collect too much useless data, or even worse too little data.

Rachael's emphasis on thinking suggests that the HBPW was instrumental in aggregating the minds-on and hands-on components of doing practical work. Perhaps the autonomy in designing procedures; choice of material, what data to collect, and how to analyse and interpret it played a part in inducing active learning. The practice of iteration was enhanced with greater student-practical work interaction due to the absence of time restrictions, which characterise LBPW. Natasha expressed this in her reflection:

> The freedom to design and carry out my own experiments forced me to apply my mind on what I was doing. I had enough time to do and redo some of the experiments especially when I was not happy with the results. On campus we work in specific time slots for practical work so, I often did not have time to do many trials.

The involvement of family members meant that the participants were not always lonely when doing HBPW. Family-student interactions emerged as unplanned but positive engagements, which enhanced active learning as they had to explain the activities to their relatives. Ntando lived in a family of four and everyone got interested in her HBPW:

> My mother and two younger sisters we surprised that I could do chemistry practical activities in our kitchen. I became a chemistry teacher in my home as I had to explain what I was doing and why. I was forced to prepare well, searching for all the information about the practical activities because I did not want to tell them I did not know. My inquisitive sisters made me feel less lonely while doing the HBPW.

HBPW Empowered the PSTs

By doing HBPW, the PSTs saw beyond achieving good grades for one specific module. They appreciated HBPW as a useful teaching strategy especially in under-resourced schools with neither conventional laboratories nor equipment to do practical activities. Forty-seven (56%) of the PSTs expressed that they would have no excuse for not doing practical work upon graduation. Sithuthukile captured this in her reflection:

> *I felt empowered by doing HBPW. I gained the courage to design and carry out practical work all by myself. I can use this strategy when I become a teacher. If I can't do practical work in the school due to limited resources or the pandemic, I can ask the learners to do some practical activities at home. I will definitely have no good reasons for not doing practical work with my learners.*

Some PSTs (42%) suggested that recording themselves doing HBPW taught them to make their own teaching resources. They also saw an opportunity to start their own YouTube channels where they would share their HBPW experiments. Timmy had this to say:

> *HBPW gave me an opportunity to create my own teaching resources. I will continue doing experiments at home, recording myself, and uploading them on my YouTube channel. It will be easy for me to refer learners to my YouTube channel to watch specific videos.*

Contextualisation Removed the Fear of Practical Work Leading to Increased Interest

Contextualisation of practical work helped to demystify learning and doing chemistry. They realised that none-conventional materials can be used to do chemistry experiments. This spurred them to commit more time to the subject. Dion shared the views of 51 (61%) other PSTs:

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> I could not believe it was me doing chemistry experiments in my home kitchen, without the beakers and volumetric flasks. I realised I could learn the subject in my home environment as much as I could do on campus with the convenience of special equipment and chemical in the chemistry lab. Using ordinary kitchen equipment and food stuffs to do experiments made me see the value of chemistry. This pushed me to do more and forget about the effects of the COVID-19 pandemic on our academic studies.

Apparently, the use of familiar materials found in the home context removed the fear of doing practical work often experienced by students in a conventional chemistry laboratory. Without fear, the PSTs developed more interest in chemistry. Dylan and 49 other PSTs alluded to this:

> In high school we didn't do a lot of chemistry practical work so, seeing all the special equipment in the laboratory mad me uncomfortable. I was afraid of breaking the glassware and getting injured by chemicals which were marked as hazardous. At home I was using material from the kitchen which I have been using since I was young. It was fun and made fall in love with the chemistry. The practical was more meaningful, I could see that chemistry happens everywhere!

The contextualisation of practical work through HBPW increased the PSTs' interest in chemistry and reinforced self-directed learning. Panashe's reflection was similar to that of 54 (64%) others:

> Doing academic practical work in my home kitchen was a wonderful experience. I enjoyed the work more than I did in the lab on campus. I had not thought of chemistry as part of my everyday life like I did when I performed the activities at home. It made me want to explore more and even do some experiments of my own during the semester break. It improved my confidence in doing practical work.

HBPW Provided Greater Autonomy and Flexibility Compared to LBPW

Almost all the participants (90%) liked the autonomy and flexibility proffered by HBPW. The opportunity to design experiments using what they could find at home was exciting and liberating. The PSTs applauded the non-restrictive nature of HBPW timewise. They had the freedom to do the practical work in their own chosen time without time limits. During LBPW sessions are timetabled and students have to complete their practical activities within a three-hour window on a specific weekday. The perceived restrictive nature of LBPW was aptly articulated by Karen in her reflection:

> I did the experiments without any jitters. I knew I had all the time in the world. In the chemistry laboratory, I struggle with accuracy because I didn't get to do enough repetitions of measurements due to limited time. Also, I enjoyed designing my own experiments based on the given topic. It allowed me to be innovative.

While the PSTs were positive about doing HBPW, there were challenges too. These included technical deficiencies, lengthy preparation time, functionality fears when exposed to conventional laboratory equipment and the impact of their socio-economic status.

Technological Deficiencies Induced Anxiety in PSTs

There was a degree of psychological discomfort induced by the requirement to video record themselves doing the experiments. At least 33 PSTs (39%) felt that the quality of their videos, due to the type of recording device, would result in low grades. Thirty-one PSTs (37%) struggled to edit and upload their videos on the e-learning platform. Molly sounded very disturbed in her journal entry:

> I do not have a high-end computer or mobile device, so my videos were of poor quality. I felt I would be marked down for this. To add to this, I am not technologically savvy, so I struggled to edit and submit my videos. I had to ask my neighbour to help me.

After realising that some PSTs had difficulties with editing and uploading their videos on the e-learning platform due to restricted file upload size, a decision was made to allow students to use platforms like YouTube or google drive to share their videos for grading.

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Resource Acquisition Made HBPW Time Consuming

Fifty-four participants (64%) reported that designing the experiments and sourcing the required materials was often time consuming. In some cases, they had to change their plans because what they wanted to use was not available in their communities. For example, Nandi could not find hydrogen peroxide to investigate the effect of a catalyst on the rate of reaction:

> My original plan was to use H_2O_2 to illustrate the effect of a catalyst on the rate of reaction. I spent half a day looking for it without success. I ended up baking which required more time and resources. The video was also too long so, editing it was another time-consuming exercise.

The PSTs' Socio-economic Status had an Impact on the Type of Practical Activities Done

Twenty-nine PSTs (35%) indicated that financial deprivation was a determinant in the quality of experiments done and videos produced. This challenge would not exist if practical work were done on campus where all the material is provided. Rafael had this to say:

> I felt that I could have done better if I had the financial resources to buy the materials I wanted to use to do the experiments as per my imagination. I would have wanted to have a kitchen weighing balance in order to use exact quantities. I ended up counting the number of spoons of baking soda. As a result, the accuracy of my measurements was poor.

Fears Regarding Practical Skills Competence

A significant number of PSTs (57%) worried about functionality in conventional laboratories when and if they retained to campus and in their professional spaces after graduating. Max asked a number of rhetorical questions in his reflections:

> Will I be good enough after the pandemic? Will I be able to use all that equipment in the chemistry laboratory? Won't I humiliate myself in front of learners one day? I feel like while I am mastering the chemistry concepts by doing practical work at home, I am missing out on some practical skills that I can only acquire in the chemistry laboratory on campus.

Discussion

The results of this research suggest that new forms of interaction emerged as PSTs did HBPW. The emergence of new forms of interaction (Anderson, 2003) can be viewed positively because they provided social interaction during a period of educational disruption and student isolation which enhanced learning. Kennepohl (2007, p. 343) suggested that family (and community) members 'offer moral support, encouragement, and contextualisation rather than access to content and experience'. Whatever their role is, the captivating power of practical work apparently extends beyond the participants to include the community. Enhanced community scientific literacy becomes an indirect benefit. HBPW possibly offers an opportunity to improve community science literacy by exposing non-traditional students to chemistry experiments and doing science in their daily lives (Casanova et al., 2006). HBPW ceased to be just another form of assessment. Student-community interactions morphed into quasi microteaching opportunities without the pressure of teaching practice assessment. This nascent, spontaneous but positive form of community service is worth building on. In essence, HBPW prompted some participants to create their own opportunities to learn, not just the chemistry knowledge and skills, but also how to teach the subject. The emergent physical interactions led to higher levels of student-content interactions as PSTs committed more time to preparing and explaining the activities to their relatives and other community members. This corroborates the work by Kennepohl (2007) who considered student-content interaction as a significant component of HBPW. The PSTs were the more capable other (Shabani et al., 2010), which pushed them to give their best possibly with the intention to impress their *found learners*. In the negative sense, the interactions may have resulted in collaborative work being graded and credited to some PSTs. The HBPW was not intended to be done collaboratively.

The less restrictive, in terms of time, nature of the HBPW was embraced by the participants. The flexibility

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of HBPW compared to LBPW was also highlighted by Kennepohl (2007). It is thought to reduce working memory overload from reading laboratory manuals hence students' unpreparedness becomes a nonfactor (Reid & Shah, 2007). This may increase the focus on scientific methods and conceptual understanding. This would be significant because LBPW has been criticised for excessive emphasis on product at the expense of processes of thought (Reid & Shah, 2007). Arguably a focus on processes of thought reinforces important scientific habits and thinking. Given the concerns about minimal or complete lack of LBPW preparation, a review of current practice is not unimaginable. Infusing out-of-laboratory practical work (OLPW) in science modules has been suggested by other scholars too (Sandi-Urena, 2020).

The use of everyday material to do the practical work, to an extent, demystified chemistry. This in turn improved students' affection for the subject and apparently enhanced their science practical work self-concept (Jansen et al., 2014). Interactions with family and the community might have played a vital role in enhancing the belief that they could do the practical work and succeed even outside a conventional laboratory. The knock-on effect could be a boost in interest and self-esteem (Al-Soufi et al., 2020) in relation to doing practical work and learning chemistry in general. The affective value of HBPW was also reported by other scholars (Al-Soufi et al., 2020; Neves et al., 2017; Nguyen & Keuseman, 2020) who worked with students outside teacher training. In the absence of intimidating conventional settings, more effective learning might have been realised through the use of familiar material (Kennepohl, 2007). Arguably, to achieve equivalent learning experiences and more, we don't have to change the experiment when the context changes.

The anxieties expressed regarding competence in practical skills derived from HBPW cannot be overlooked. Similar concerns were highlighted by other scholars focusing on kitchen chemistry (Lyall & Patti, 2010). While HBPW provides similar sensory experiences, it is perceived as deficient in the accuracy and precision required under scientific methods. The reliability of measurements is important 'if students are to appreciate the experimental basis of the discipline' (Casanova et al., 2006, p. 501).

HBPW provided a reminder of the issue of equity in science education. Some students could not afford to acquire materials they wanted to use, which limited their options when designing experiments, and others lamented the quality of their video recordings. While lecturers can design and use assessment rubrics to minimise subjective grading, the psychological impact it has on the students should not be underestimated. This highlights the difficulty of effectively mediating practical work outside the conventional chemistry laboratory (Kennepohl, 2007) because access to material, technology, and incongruent student home environments are persistent concerns exacerbated by the COVID-19 pandemic (Van Heuvelen et al., 2020).

While the PSTs' reflections suggest positive experiences, this research falls short of systematically determining the effectiveness of HBPW in achieving the intended educational outcomes. Notwithstanding this limitation, the findings of this research provide insight into the potential of this instructional approach and student-community interactions in contexts where LBPW is not possible.

Conclusions

This study explored PSTs' experiences of HBPW through an analysis of their reflections. Their physical and virtual interactions provided useful insights on HBPW. The equivalency theorem provided a framework for understanding the results. Among other forms of interaction, the unanticipated emergence of student-community interactions provides an invaluable opportunity for students to learn how to teach under remote learning. This can be done in a more organised way under the methodology modules with students sending video recordings of themselves doing self-designed practical work with high school learners in their communities.

Students' experiences suggest that HBPW can be a viable alternative to LBPW, especially in times of a pandemic where contact sessions are not possible. However, the diversity of socio-economic contexts implies that learning experiences may not be uniform. As such, alternative ways of enacting HBPW need to be explored. One way of equilibrating the situation would be providing a home laboratory kit (HLK) to each student. Each HLK would contain a standard set of conventional chemistry laboratory equipment and chemicals that would enable students to do the prescribed practical work for chemistry modules. Lecturers can agree on the contents of the HLK in order to cover a range of modules and practical competences as defined by the curriculum. Compactness, portability, durability, and the cost of purchasing and shipping to students would be key considerations.

Students welcomed the autonomy and flexibility offered by HBPW. Perhaps this calls for a review of how LBPW is done. A balance between efficiency and effectiveness in LBPW might help to achieve better outcomes. An option

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to consider would be to assign students LBPW to design and carry out in their own time during a time window. However, this might be difficult to achieve if student numbers are large and laboratories are small.

While HBPW was generally embraced by the participants, there is a need to research on its effectiveness, particularly in teacher training programmes, given the concerns about its limitations in developing practical skills. Determining if there is a significant difference between the performance of the students in HBPW compared to LBPW as well as the difference in performance between the students who had student-family or student-community interactions and those who did not may provide useful insights.

References

Al-Soufi, W., Carrazana-Garcia, J., & Novo, M. (2020). When the kitchen turns into a Physical Chemistry lab. *Journal of Chemical Education, 97*(9), 3090-3096. https://doi.org/10.1021/acs.jchemed.0c00745?ref=pdf

Anderson, T. (2003). Getting the mix right again: An updated and theoretical rationale for interaction. *The International Review of Research in Open and Distributed Learning, 4*(2), 1-14. https://doi.org/10.19173/irrodl.v4i2.149

Anderson, T., & Garrison, D. R. (1998). Learning in a networked world: New roles and responsibilties. In C. Gibson (Ed.), *Distance learners in higher education* (pp. 97-112). Atwood Publishing. https://auspace.athabascau.ca/bitstream/handle/2149/801/learning_in_a.pdf?sequence=1

Ashworth, S. (2018). Kitchen Chemistry: history and development. *Chemistry in Action!, 111*, 29-35. https://ueaeprints.uea.ac.uk/id/eprint/67129/1/2018_CinA_111_Spring_2018_1_.pdf

Boschmann, E. (2003). Teaching chemistry via distance education. *Journal of Chemical Education, 80*(6), 704-708. https://doi.org/10.1021/ed080p704

Brewer, S. E., Cinel, B., Harrison, M., & Mohr, C. L. (2013). First year chemistry laboratory courses for distance learners: Development and transfer credit acceptance. *International Review of Research in Open and Distributed Learning, 14*(3), 488-507. https://doi.org/10.19173/irrodl.v14i3.1446

Carnduff, J., & Reid, N. (2003). *Enhancing undergraduate chemistry laboratories: pre-laboratory and post-laboratory exercises*. Royal Society of Chemistry.

Casanova, R. S., Civelli, J. L., Kimbrough, D. R., Heath, B. P., & Reeves, J. H. (2006). Distance learning: A viable alternative to the conventional lecture-lab format in general chemistry. *Journal of Chemical Education, 83*(3), 501-507. https://doi.org/10.1021/ed083p501

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8 ed.). Routledge.

Creswell, J. W. (2015). *A concise introduction to mixed methods research*. Sage Publications.

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative & Mixed Methods Approaches*. Sage.

Denzin, N. K., & Lincoln, Y. S. (2018). *The Sage Handbook of Qualitative Research* (5 ed.). Sage Publications.

Fani, T., & Ghaemi, F. (2011). Implications of Vygotsky's zone of proximal development (ZPD) in teacher education: ZPTD and self-scaffolding. *Procedia-Social and Behavioral Sciences, 29*, 1549-1554. https://doi.org/10.1016/j.sbspro.2011.11.396

Gilbert, J. K. (2006). On the nature of "context" in chemical education. *International Journal of Science Education, 28*(9), 957-976. https://doi.org/10.1080/09500690600702470

Hodges, C. B., Moore, S., Lockee, B. B., Trust, T., & Bond, M. A. (2020). The difference between emergency remote teaching and online learning. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Ivanitskaya, L., Clark, D., Montgomery, G., & Primeau, R. (2002). Interdisciplinary learning: Process and outcomes. *Innovative Higher Education, 27*(2), 95-111. https://doi.org/10.1023/A:1021105309984

Jacobsen, E. K. (2011). Kitchen Chemistry. *Journal of Chemical Education, 88*(8), 1018-1019. https://doi.org/10.1021/ed200359x

Jansen, M., Schroeders, U., & Lüdtke, O. (2014). Academic self-concept in science: Multidimensionality, relations to achievement measures, and gender differences. *Learning and Individual Differences, 30*, 11-21. https://doi.org/https://doi.org/10.1016/j.lindif.2013.12.003

Kennepohl, D. (2007). Using home-laboratory kits to teach general chemistry. *Chemistry Education Research and Practice, 8*(3), 337-346. https://auspace.athabascau.ca/bitstream/handle/2149/1814/CERP2007.pdf?sequence=1&isAllowed=y

Kennepohl, D. (2010). Remote control teaching laboratories and practicals. In D. Kennepohl & L. Shaw (Eds.), *Accessible Elements: Teaching Science Online and at a Distance* (pp. 167-187). AU Press.

King, D. (2012). New perspectives on context-based teaching: Using a dialectical sociocultural approach to view teaching and learning. *Studies in Science Education, 48*(1), 51-87. https://doi.org/10.1080/03057267.2012.655037

Kitzmann, K., & Otto, C. (2008). Chemistry and unifying themes of science. In S. L. Bretz (Ed.), *Chemistry in the National Science Educational Standards: Models for meaningful learning in the high school chemistry classroom (2 ed.)* (pp. 21-28). American Chemical Society Education Division. .

Lyall, R., & Patti, A. T. F. (2010). Taking the chemistry experience home: Home experiments or "Kitchen Chemistry". In D. Kennepohl & L. Shaw (Eds.), *Accessible Elements: Teaching Science Online and at a Distance* (pp. 83-108). AU Press. http://oer4nosp.col.org/id/eprint/105/1/Accessible_Elements.pdf#page=111

McDonnell, C., O'Connor, C., & Seery, M. K. (2007). Developing practical chemistry skills by means of student-driven problem based learning mini-projects. *Chemistry Education Research and Practice, 8*(2), 130-139. http://eprints.teachingandlearning.ie/2942/1/McDonnell%20et%20al%202007%20seery%20paper%20final_tcm18-85037.pdf

https://doi.org/10.33225/jbse/21.20.894

Mertens, D. M. (2020). *Research and Evaluation in Education and Psychology: Integrating Diversity With Quantitative, Qualitative and Mixed Methods* (5 ed.). Sage.

Neves, B.-H. S., Altermann, C., Gonçalves, R., Lara, M. V., & Mello-Carpes, P. B. (2017). Home-based vs. laboratory-based practical activities in the learning of human physiology: the perception of students. *Advances in physiology education, 41*(1), 89-93. https://doi.org/10.1152/advan.00018.2016

Nguyen, J. G., & Keuseman, K. J. (2020). Chemistry in the Kitchen Laboratories at Home. *Journal of Chemical Education, 97*(9), 3042-3047. https://doi.org/http://dx.doi.org/10.1021/acs.jchemed.0c00626

Nja, C. O., Cornelius-Ukpepi, B., Edoho, E. A., & Neji, H. A. (2020). Enhancing students academic performance in Chemistry by using kitchen resources in Ikom, Calabar. *Educational Research and Reviews, 15*(1), 19-26. https://doi.org/10.5897/ERR2019.3810

Nuora, P., & Välisaari, J. (2020). Kitchen chemistry course for chemistry education students: influences on chemistry teaching and teacher education – a multiple case study. *Chemistry Teacher International, 2*(1), 1-10. https://doi.org/https://doi.org/10.1515/cti-2018-0021

Reid, N., & Shah, I. (2007). The role of laboratory work in university chemistry. *Chemistry Education Research and Practice, 8*(2), 172-185. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.135.3250&rep=rep1&type=pdf#page=76

Sandi-Urena, S. (2020). Experimentation skills away from the chemistry laboratory: Emergency remote teaching of multimodal laboratories. *Journal of Chemical Education, 97*(9), 3011-3017. https://doi.org/10.1021/acs.jchemed.0c00803

Schultz, M., Callahan, D. L., & Miltiadous, A. (2020). Development and use of kitchen chemistry home practical activities during unanticipated campus closures. *Journal of Chemical Education, 97*(9), 2678-2684. https://doi.org/10.1021/acs.jchemed.0c00620

Seery, M. K. (2020). Establishing the laboratory as the place to learn how to do chemistry. *Journal of Chemical Education, 97*(6), 1511-1514. https://doi.org/10.1021/acs.jchemed.9b00764

Shabani, K., Khatib, M., & Ebadi, S. (2010). Vygotsky's zone of proximal development: Instructional implications and teachers' professional development. *English language teaching, 3*(4), 237-248. https://files.eric.ed.gov/fulltext/EJ1081990.pdf

Tan, V., Crow, L., Gibson, A., Phillips, C., Wray, L., & Reck, C. (2019). Chemistry in the Kitchen. *The Science Teacher, 86*(9), 32-39. https://www.jstor.org/stable/pdf/26899170.pdf

Van Heuvelen, K. M., Daub, G. W., & Ryswyk, H. V. (2020). Emergency remote instruction during the COVID-19 pandemic reshapes collaborative learning in general chemistry. *Journal of Chemical Education, 97*(9), 2884-2888. https://doi.org/10.1021/acs.jchemed.0c00691

Yin, R. K. (2016). *Qualitative research from start to finish* (2 ed.). The Guilford Press.

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