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Take-home Examination Proctoring Technologies: Undergraduate Mathematics Education Students' Perceptions in an Open Distance Learning Environment

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Abstract: Many higher education institutions (HEIs) in both developed and developing countries have migrated to take-home examinations (THEs), which require monitoring, just as traditional venue-based examinations do. The purpose of this existential phenomenological study was to explore undergraduate mathematics education students' perceptions of the use of remote proctoring during examinations at an open and distance learning institution in South Africa. Perception theory was employed to examine the usefulness and ease of use of technology to guide the study. The interpretive paradigm was used to qualitatively analyse the collected data. Twenty-four undergraduate mathematics education students enrolled in the Teaching Mathematics in FET (TMS3725) module were purposively sampled to respond to an open-ended questionnaire. The data were captured in a table and grouped according to question items. Thematic analysis was conducted to analyse the data collected from the questionnaires. The findings revealed positive perceptions of the usefulness and usability of online proctoring systems. However, negative perceptions related to the drawbacks of using online proctoring systems included students' reactions to these systems and potential technical problems. It is recommended that students continue attending online proctoring workshop sessions to become familiar with technological software that can be both useful and easy to use during examinations. Additionally, the technical team should continue to provide support to students in using online proctoring systems during examinations.

Keywords: Online proctoring system, open distance learning, students' perceptions, take-home examination.

1. Introduction

Many higher education institutions (HEIs), in both developed and developing countries, have migrated to take-home examinations (THEs), which require monitoring similar to traditional venue-based examinations, using online proctoring systems (OPSs) (Lee & Fanguy, 2022). HEIs primarily adopted such systems due to the Covid-19 outbreak in 2019/20, and OPSs continue to be utilised beyond the pandemic (Andreou et al., 2021; Hamamoto Filho et al., 2021; Lee et al., 2021). The use of OPSs during THEs has also gained popularity among HEIs in the African context (UNESCO, 2022). UNESCO has advocated for and approved proctoring systems as they provide a training ground for the social, intellectual, and psychological development of both students and teachers. South Africa is one of the African countries that transitioned to online learning and assessment—processes that require invigilation, similar to what occurs at traditional residential contact-based universities (Methi, 2023). The University of South Africa (Unisa) is an open distance e-learning (ODeL) institution that has adopted THEs and employs OPSs to monitor the process, thus protecting academic integrity and preventing academic dishonesty among students. At Unisa, the primary OPS used is the Invigilator App, which also manages and controls the process of THEs.

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OPS is a service that establishes invigilated examination conditions outside of the exam hall (Dawson, 2020). Online proctoring creates a remote version of exam hall conditions by monitoring and restricting opportunities for (illicit) action and movement (Fawns & Schaepkens, 2022). The technology verifies each candidate's identity, checking that they are alone and isolated from resources that could aid their performance (Fawns & Schaepkens, 2022). In this context, wearing ear buds or handling textbooks or unauthorised mobile devices may be considered a "serious breach of exam protocol" (MRCPUK, 2020). Lee et al. (2021) note that OPS is a monitoring and controlling system, similar in purpose to traditional pen-and-paper invigilation, designed to protect academic integrity. Fawns and Schaepkens (2022) add that OPSs monitor movement and inappropriate actions during the THE period. These scholars further assert that OPS protects academic integrity and can verify a student's identity to ensure that they are alone and do not have resources around them. Lee and Fanguy (2021) posit that OPS detects and reports any malpractices occurring during THEs.

Prior to the implementation of OPS in HEIs, educators were pressured to resort to online teaching and did so but were insufficiently prepared for THEs, having largely disregarded the assessment process (Lee et al., 2021). The lack of preparedness in administering THEs, using the same tools as for live lectures, led to an increased number of student cheating behaviours (Lee & Fanguy, 2021). OPSs were introduced to monitor THEs, to safeguard academic integrity and prevent students from cheating in the exams.

The implementation of OPS requires exam-takers to install software on their devices to block access to documents, applications, and websites (Fawns & Schaepkens, 2022). Students download their exams using a secure browser to ensure that no other computer resources are used to cheat (Nigam et al., 2021). The question paper needs to be designed to reduce the number of common questions students can answer (Nigam et al., 2021). Existing research focuses on the potential advantages of using remote proctoring to ensure academic integrity, monitor test-taker behaviour, and combat inappropriate behaviour (Berkey & Halfond, 2015; Hamamoto Filho et al., 2021; Langenfeld, 2020). To a lesser degree, the body of research explores usability and user reactions to remote proctoring and addresses potential implementation issues, obstacles, and technical difficulties that might arise (Castaño et al., 2020; Gudiño Paredes et al., 2021).

When evaluating research and exploring the impact of remote proctoring on student outcomes, the available literature tends to compare proctored to unproctored exams (Dendir & Maxwell, 2022; Hollister & Berenson, 2009). To date, there has been a paucity of research exploring ODeL students' perceptions of the use of OPS during THEs, particularly among those exposed to the Invigilator App. In keeping with the purpose of the study, which is to explore undergraduate mathematics education students' perceptions of the use of OPSs during examinations at an ODeL institution, the Invigilator App was introduced and used to monitor examinations at Unisa's College of Education. To achieve the aim of using this app, ensuring that THEs are administered smoothly and without any cheating, students need to use it before the examination starts. No illicit or unauthorised materials that could disrupt the smooth running of the examinations may be present.

Gaining a comprehensive understanding of first-year mathematics education students' perceptions of the use of an OPS during their at-home exam was deemed essential to revealing how the app could be used with fewer obstacles (if any). To that end, the researcher sought to answer the following research questions: 1) *What are ODeL undergraduate mathematics education students' perceptions of the use of OPSs during THEs?* and 2) *What challenges do students face when using OPSs during THEs?* As indicated below, the existing literature was consulted regarding the usefulness of proctoring online exams, the usability of OPSs during THEs, and the associated setbacks. Next, the focus shifts to the use of perception theory to underpin the study and the research methods employed, followed by an analysis and discussion of the findings obtained from the collected data. The article concludes with recommendations and a summary.

2. Related Literature

The literature pertaining to the topic under study focuses on three main issues: the usability of online proctoring exams, the effectiveness of such proctoring, and the reported setbacks.

2.1 Usefulness of OPSs during THEs

Studies have confirmed the usefulness of OPSs during THEs (Alessio et al., 2017; Andreou et al., 2021; Berkey & Halfond, 2015; Hamamoto Filho et al., 2021; Langenfeld, 2020). Alessio et al. (2017) note that an OPS activates the computer or laptop to record all activities during a THE while restricting numerous computer applications (Arnò et al., 2021). As Coghlan et al. (2021) confirm, OPSs can identify candidates' suspicious behaviours during THEs. Fawns and Schaepkens (2022) support the notion that OPSs monitor and constrain any prohibited actions and movements during THEs. Lee and Fanguy (2022) indicate that OPSs identify students' identities to verify whether they are alone in their settings and have no access to resources that can aid their performance.

Andreou et al. (2021) posit that OPSs allow lecturers to assess many students simultaneously, thereby maintaining academic integrity. Specialist providers monitor students' activities throughout the exams, just as they would in venue-based examinations (MRCPUK, 2020). A study by Meulmeester et al. (2021) in the Netherlands found that OPSs prevented fraud during THEs and were essential for the continuation of students' education and graduation. In addition, Almutawa and Sruthi (2021) and Reisenwitz (2020) found in their respective studies that the use of OPSs prevented the risks of plagiarism and cheating during examinations. In Italy, De Santis et al. (2020) reported that OPSs were useful for monitoring students' behaviour and integrity by checking their desktop activity throughout the entire course of a THE.

2.2 Usability of OPSs during THEs

In New Zealand, Harnett et al. (2023) found that more than 50% of students perceived OPSs as easy to use. In their study, 56% of student participants indicated that the technology was easy to use, clear, understandable, and convenient to access. This was compared with 23% of participants who disagreed and 21% who remained neutral. Raman et al. (2021) and Selwyn et al. (2021) found a strong positive correlation between students who confirmed the perceived ease of use of OPSs, those who were satisfied with the experience, and those who were confident about completing their exams in the location of their choice. Most of the student participants in a study by Aguilera-Hermida (2020), who appreciated the perceived ease of use of OPSs, were found to have the appropriate digital devices and stable internet connections. In the Harnett et al. (2023) study, most student participants (66%) reported being digitally competent, were reasonably self-reliant at solving frequent technical problems that occurred during THEs, and perceived the use of OPSs as easy. Harnett et al. (2023) further found that most participants were reasonably confident they had the competence to complete their THEs using OPSs. Adanır and Çınar (2021) and Kharbat and Abu Daabes (2021) believe that OPSs are easier to use when students possess the requisite technical knowledge and skills, while Hosseini et al. (2021) and Linden and Gonzalez (2021) recommend that students have the opportunity to use the system prior to commencing a THE and be offered technical support if needed. Being familiar with OPSs when used during THEs can reduce examinees' stress and anxiety, according to Hosseini et al. (2021).

Meulmeester et al. (2021) found that medical students felt at ease writing exams at home using OPSs. As Balash et al. (2021), in a study at Washington University, reported, 30% of the student participants preferred using OPSs to monitor and prevent dishonesty during THEs. Moreover, according to the authors, more than half of the participating HEIs in that study preferred to use OPSs in remote examinations to curb cheating (Balash et al., 2021). The participants in a study by Nicola-Richmond et al. (2023) found OPSs simple to use and preferred to write examinations at home before returning to everyday life.

Most scholars reported that students felt comfortable using OPSs during THEs, as they knew what to do during remote examinations. Lilley et al. (2016) support the idea that students have positive perceptions about the usability of OPSs since they could use their own devices to complete their assessments without significant challenges. Nicola-Richmond et al. (2023) found that, thanks to the usability of OPSs, students found remote exams more appealing than venue-based assessments.

2.3 Setbacks of OPSs during THEs

Although OPSs in THEs have their usefulness, the literature identifies several setbacks. Langenfeld (2020) and Selwyn et al. (2021) report concerns about using OPSs due to the potential invasion of examinees' privacy. Nicola-Richmond et al. (2023) note that writing THEs under the surveillance of OPSs can cause stress and anxiety for students. Additionally, OPSs can present challenges when there is a lack of private space, devices are of low quality, and internet connectivity is poor (Coghlan et al., 2021).

Contrary to the previous findings mentioned here, Dawson (2020) suspects that completing exams' at home' using OPSs may compromise academic integrity and foster academic dishonesty. As Stapleton and Blanchard (2021) argue, the use of OPSs in these contexts can facilitate cheating if the camera is not positioned correctly. Mutuwa (2021) found that the time allotted for THEs using OPSs negatively affects students' academic achievement and their satisfaction with this type of proctoring. Moreover, this scholar discovered that study participants expressed dissatisfaction with using OPSs, as some were reluctant to record the examination process. Harnett et al. (2023) add that, in their study, student participants displayed negative attitudes towards the use of OPSs during THEs, as it increased their anxiety about potentially being accused of cheating during the online examination process.

3. Theoretical Lens

The concepts of perception theory – regarding positive perceptions, negative perceptions, perceived ease of use, and perceived usefulness – underpin this study, as the researcher seeks to understand the student participants' perceptions of the implementation of OPSs in administering THEs. Irwanto (2002) describes perception as an active bodily process during which a person receives stimuli from objects, then interrogates the qualities and relationships between symptoms and events until the stimuli are understood. Broadbent (1959) defines perception as a process in which an individual selects, organises, and interprets information to make sense of the environment, ultimately identifying, retrieving, and responding to that information. Based on these definitions, perception is the experience and feeling an individual has regarding the perceived object.

Solso et al. (2007) identify two forms of perception: positive and negative perceptions. With positive perception, all responses and knowledge that can be associated with the perceived object are activated, accepted, and supported. Chukwuere (2021) views positive perceptions as responses linked to the fact that the perceived object advances learning. In contrast, negative perceptions involve responses and knowledge that do not support the perceived object, which can be opposed and/or rejected. Thoha (2003) identifies two factors influencing individuals' perceptions: internal and external. Internal factors include psychiatric disorders, attitudes, motivations, attention (focus), learning processes, physical states, needs and values, interests, feelings, desires, and hopes. As Davis (1989) specifies, two external factors influence an individual's perception: usefulness and ease of use.

Perceived usefulness is the belief that an individual is convinced that using a particular system would help him or her perform a job better (Davis, 1989). Venkatesh and Bala (2008) view perceived usefulness as the application of information to enhance work performance. In other words, if the use of an OPS monitors and prevents fraud during THEs, then it is deemed useful. Perceived ease of use refers to an individual's belief that a particular system will be straightforward to adopt, requiring no significant effort to use the relevant information technologies (Venkatesh & Bala, 2008). More

specifically, OPSs are viewed more favourably if the majority of examinees find them easy to use during THEs.

This study has embraced the four concepts of perception theory to shape the formulated research questions, which are clearly aligned with these concepts. In responding to the questions, the participants provided the researcher with insights into their perceptions of the use of OPSs during THEs and the associated challenges. The aforementioned four concepts played a major role in the design of an open-ended questionnaire as a data-collection instrument. Notably, they also contributed to the analysis and interpretation sections outlined in the methodological approach to this study.

4. Research Methods

To answer the research questions of this study, the interpretivist paradigm was employed to interpret the experiences and meanings attributed to the use of OPSs during THEs by the students, as suggested by Williamson and Johnson (2018). This paradigm reflects research practices that provide insight into study participants' perspectives in navigating multiple realities. A qualitative approach was adopted to describe the phenomenon under investigation and to uncover a new and deeper understanding of the ease of use and usefulness of OPSs during THEs. In qualitative research, data is collected in a setting where participants engage with the scenario under investigation. Qualitative researchers gradually make sense of a social phenomenon by comparing, contrasting, replicating, cataloguing, and classifying the object of study. This study employed an existential phenomenological research design to understand the perceptions of undergraduate mathematics education students regarding the use of OPSs during exams. This research design enabled the researcher to gain insight into the lived meanings that participants constructed and their experiences within the field of study (Churchill, 2021).

The current study was conducted with undergraduate students enrolled in the module Teaching Mathematics in the FET in the Department of Mathematics Education at the University of South Africa (Unisa). A total of 367 students had enrolled in this module and were approached to participate in the research. An open-ended questionnaire was administered to 24 students who volunteered to take part. The researcher sent emails to distribute the questionnaire, while the students returned their responses via email. As the study was conducted in an ODeL environment, these HEI students came from different countries, provinces, and districts, thus there was only a minimal chance that the participants would share ideas about the questions. Thus, by employing purposive sampling, as Creswell and Creswell (2023) note, researchers can intentionally select the participants and the sites. The questionnaire was developed in line with perception theory and was piloted with five students to verify whether the questions would assist in addressing the research questions and to identify possible duplications. The questionnaire questions were found to be comprehensible and appropriate for responding to the research questions, and no duplications were identified.

4.1 Ethical issues

The researcher sought consent from 24 student volunteers to participate in the study and established rapport by explaining the purpose and rationale of the undertaking. A blanket ethical clearance certificate was obtained for the scholarship of teaching and learning in the College of Education at Unisa (REF2018/03/14 90060059MC). The students were assured that their demographic and other information would be treated confidentially, with codes used to protect their identities. Since their participation was voluntary, they could withdraw from the study at any stage without being prejudiced or penalised. The student participants were assured that their data would be used solely for the purposes of this study, that the data would be encrypted, and that it would only be accessed by the researcher before being deleted from the system after five years.

4.2 Data analysis procedures

This study utilised thematic data analysis to interpret students' perceptions of the use of OPSs during THEs by identifying patterns and themes emerging from the transcribed responses to the questionnaire instrument. Trustworthiness was achieved by ensuring the rigor and quality (Williamson & Johnson, 2018) of this undertaking. Member checking was conducted with participants reviewing the captured datasets, which were transcribed using Microsoft Excel.

The researcher repeatedly read through the raw datasets from the transcriptions to become familiar with the material and the relevant information related to the identified research questions. Re-reading the datasets assisted the researcher in classifying and reducing the data into themes for reporting purposes. The accuracy of the derived themes was compared with the generated datasets. Thematic analysis facilitated the formation of connections between the research objectives and the findings obtained from the raw data, allowing for the condensation of the varied datasets into summaries.

The researcher ensured that the process of arriving at the themes would be transparent (demonstrable to others) and defensible (justifiable given the study's objectives). The datasets were assessed by comparing the findings with previous studies and obtaining feedback from the student participants to ensure trustworthiness. Codes were assigned, for example, SQ1, SQ2, SQ3 … SQ24, for those who responded to the questionnaires.

4.3 Methodological approach

This section discusses how perception theory was employed to understand participants' perceptions of the use of OPSs during THEs (see Tables 1 and 2). Table 1 presents the main concepts, their descriptions, and the performance indicators of perception theory. Additionally, Table 2 provides the absolute numbers and relative frequencies of the codes and categories used to identify trends: majority, average, and minority in terms of positive and negative perceptions, perceived usefulness, and perceived ease of use. This theory helped reveal the experiences and feelings participants had towards the perceived object. This type of coding study followed the formula: assessment system acceptance, assessment system denial, using the assessment system is effortless, and the assessment system is useful. The main concepts of the framework were defined, and the performance indicators were described.

Table 1: *Methodological approach*

Concept	Description	Performance indicator
Positive perception	All responses and knowledge that can use the perceived object, and this will be continued by activating or accepting and supporting it	- When students accept and support the implementation of OPSs in monitoring THEs
Negative perception	No responses and little knowledge to support the perceived object, and can oppose and reject the perceived object	- When students oppose or reject the use of OPSs to monitor the process of THEs - The OPS is not easily accessed - Technical problems
Perceived usefulness	The perception, by an individual, who believes using a particular system would help him/her do the job better	- Students view OPSs as useful in monitoring the process around THEs

		- It helps the HEI to protect academic integrity and prevent academic dishonesty
Perceived ease of use	When an individual believes a particular system is easy to use	- Students concur that OPSs are easily accessible - Shown to have minimal problems

Table 2 presents the absolute frequencies of the coded and categorised textual excerpts in identifying trends such as majority, average, and minority groups of participants, regarding their perceptions of the online assessment system. The frequency table used absolute numbers representing the number of participants for their negative perceptions, positive perceptions, the perceived usefulness of OPSs, and their perceived ease of use. The majority group of students is categorised as $12 < x \leq 24$, the average group as $8 < x \leq 12$, and the minority as $1 \leq x \leq 7$.

Table 2: *Frequency table (absolute number)*

Concept	Negative perceptions	Positive perceptions	Perceived usefulness	Perceived ease of use
Frequency	12	19	21	18

5. Presentation of Findings

According to Lee and Fanguy (2022), OPS is a monitoring and control system that detects and reports malpractices during exams conducted outside of formal venues. Fawns and Schaepkens (2022) explain that the OPS monitors movements and inappropriate actions during these exams. All 24 student participants returned their questionnaires via email. After repeatedly reading the transcriptions, the researcher identified both positive and negative perceptions of the use of OPS during THEs. The following themes emerged: The significance of OPSs during THEs, the setbacks of using OPSs, and potential technical challenges.

5.1 The significance of OPSs during THEs

The findings showed the extent of OPS use during THEs, revealing its usefulness and usability as advantages. Its usefulness was highlighted when respondents indicated their acceptance and support for the use of these systems during non-venue-based exams. The OPS was considered useful as it could monitor activity, protect academic integrity, and prevent cheating. Additionally, participants noted that the use of OPS allowed them to perform according to their abilities, which might not be the case in the confines of venue-based examinations. Excerpt 1 presents the participants' perceptions of the usefulness of OPSs (quoted verbatim), with their identities anonymised through coding.

Excerpt 1: *Sample of students' responses*

SQ3	I found Invigilator App [the OPS] […] useful as it monitors the examination and prevent[s] cheating. It is also useful as those who used to cheat during exam hall examinations cannot cheat because the app can detect everything in our places.
SQ7	This app is good as it prevents cheating, some students used to cheat in the venue-based examinations without being noticed. It can observe any movement in the room, and you cannot access any material on your computer. Students get what they deserve.
SQ12	I found this app […] useful [for] doing thorough monitoring of exams, [more so] than the venue-based examinations. Some students were used to cheat[ing] without being noticed by the invigilators and this app observes each action or

	movement of the students during online examination. There is no cheating at all with this app and [it] can show when you switch[ ] it off.
SQ	This app is good in preventing cheating as [it] can observe everything in the room. Cheating was sometimes appearing to occur during venue-based examinations without invigilators noticing them.

As these responses revealed, the participants found an OPS to be more useful than face-to-face invigilation, as the system can monitor all movement in the venue. The comments indicated that some students used to cheat during venue-based examinations but now find it difficult to engage in malpractice during exams because the Invigilator App would capture such actions. Moreover, the participants highlighted that cheating had become more difficult, as examinees cannot access any materials on the computer during THEs.

The participants emphasised the usability of OPSs during non-venue-based assessments, as they are easy to access and use. They expressed confidence in using OPSs and felt comfortable doing so. Excerpt 2 presents their perceptions of the usability of OPSs during THEs.

Excerpt 2: *Sample of students' responses*

SQ2	The app is easy to use, it just needs one to have a smartphone or a computer connected to [the] internet. After downloading the question paper, you can just switch it on, and it will just capture everything in the room.
SQ15	This Invigilator App does not have a problem, you can open it easily and it starts taking all the pictures in the room without any problem. Initially I thought it [would] have problems, but I found it […] easy to use during the examination.
SQ17	In the beginning I thought this [would] give us a problem when we write an exam, I have easily accessed it and open[ed] it. It is easy to open as we […] attended […] training on using it. So we […] practised how to use it before [the] exams.

Highlighted here is the usability of the OPS during THEs, with participants finding the system easy to use and facing minimal challenges. They reported valuing the training they had received beforehand, and the only issue with the OPS was that devices had to be in good working condition, and the internet connection had to be stable. Furthermore, although the app demonstrated ease of use, a technical team was always available to support those who struggled to use it during exam sessions.

5.2 Setbacks of OPSs

The findings revealed certain aspects that created negative perceptions among students regarding the use of OPS during THEs. The identified factors included a lack of private space, the risk of cheating if the camera is not appropriately positioned, student anxiety, invasion of privacy, heightened stress levels, and distractions during examinations. Excerpt 3 presents the respondents' negative perceptions of the use of OPS during non-venue-based exams.

Excerpt 3: *Sample of students' responses*

SQ1	This app causes anxiety because if you can be distracted, then your script will [not] be marked and [you] will have to write [a] supplementary examination. Again, we do not have privacy as some do not have a private space to write examinations, and this affects our performance.
SQ8	I feel like my space is invaded and [I] have no privacy, as some of us are living in a one- or two-room[ ] house, with all [our] belongings packed in one place. We may sometimes have stress if the action completed is blurred and you must

	repeat it, and our performance will be poor. This will take your actual time [when] writing exam[s].
SQ11	The problem is when the app wants to see the script and [I] show[ ] a blank script, [I] become anxious as my whole exam may be affected, including my performance. Sometimes [the] level of stress will increase because if the app does not work well, you will have to repeat one thing many times.
SQ17	This App invade[s] our privacy because some of us do not our own private space to write exam[s]. Sometimes we are stress[ed], especially when the camera shows blurry and dark photos, and the software that processes the pictures does not allow flashes. Stress always affect[s] performance.

The participants claimed to be uncomfortable when using an OPS during an assessment, as the software that captures their pictures and scripts takes blurred or dark images. In addition, the participants indicated that the software sometimes does not function, which eats into their actual exam time, as they need to repeat an activity or step in the process. Also, using the OPS was deemed to invade their privacy, as most of them do not have a private space in which to take their exams, and this causes them stress during THEs.

5.3 Potential technical challenges

The findings revealed that undertaking THEs using an OPS has its own technical problems, including slow internet connections (which affect the effectiveness of the OPS), sub-par devices due to students coming from different socio-economic backgrounds, and loadshedding (erratic power supply). Excerpt 4 presents the participants' perceptions of the potential technical problems associated with using OPSs during THEs.

Excerpt 4: *Sample of students' responses*

SQ1	The challenge in using [the] Invigilator App is loadshedding, as it interrupts us when undertaking online exams. This causes a problem because our exams will be affected and our scripts may not be marked.
SQ5	In our area network connection is always slow, and [I'm] not sure what the problem is, and this affects [the] Invigilator App. This causes a problem as the exam will be interrupted, as the use of the app is compulsory during exam[s].
SQ19	Sometimes I become anxious during exams because of technical problems, as [the] electricity… power … is on and off in our place, and [that] may affect our monitoring system, and those who are used to cheat[ing] may have a chance to cheat. This will disadvantage other students who are not used to cheat[ing].
SQ23	Our App is mostly affected by loadshedding and low internet connecti[vity] which affect[ ] our performance as [we] will start to panic during exams.

The quotes highlighted the fact that technical problems cause examinees emotional distress and affect their performance. Moreover, technical issues decrease the actual time they have to complete an examination, such as when taking pictures of blank answer scripts and photos of themselves, which appear to be blurry or too dark to identify the individual.

6. Discussion of Findings

Generally, the participants shared positive perceptions of the use of OPSs during THEs, in terms of monitoring, detecting, and reporting malpractices that may influence the outcomes of formal assessments. The participants agreed on the usefulness and usability of OPSs in protecting academic integrity and preventing student dishonesty. These findings are supported by Lee and Fanguy (2022) and De Santis et al. (2020), who found that the use of OPSs in THEs monitored movement and inappropriate actions, detecting and reporting malpractices during the invigilation process. The

participants reportedly preferred OPSs to face-to-face invigilation, as it allowed them to complete their exams and then continue with their daily activities. This aligns with the views of Nicola-Richmond et al. (2023), who found that students prefer THEs to face-to-face examinations.

As mentioned, the findings confirmed the usability (ease of use) of OPSs, as the study participants appeared to access and implement the system easily with minimal challenges, having been trained to use the software prior to taking THEs. Moreover, they showed self-confidence and were comfortable using the system, as the university offered technical support during the examination. This finding echoes that of Harnett et al. (2023), who found that students in New Zealand were confident about, and competent at, using OPSs. Hosseini et al. (2021) advise that students need to use OPSs prior to the commencement of online examinations and must be offered technical support to strengthen the usability of any invigilation system.

Although the findings confirmed the usefulness and usability of OPSs, the participants expressed negative perceptions of the systems, arguing that the software increased their stress levels and anxiety, especially when it failed them. Nicola-Richmond et al. (2023) concur that the use of OPSs when undertaking non-venue-based exams can cause students stress and anxiety. The participants argued that OPSs invade their privacy, as most of them lack private space in their homes to study. Furthermore, such an invasion of privacy caused many participants to feel uncomfortable during THEs, which they claimed affected their academic achievement. This confirms the findings of Coghlan et al. (2021), which indicate that there are negative effects of OPS use, including the lack of a safe and private space, which can hamper students' academic performance.

In the findings, potential technical problems that compromised the use of OPSs were highlighted. Erratic internet connectivity and load shedding reportedly hampered the effective use of OPSs, which are intended to help safeguard academic integrity and prevent cheating. This was evident when the participants reportedly struggled to take their photos and scan their answer scripts, with such delays minimising the time available to complete the exam. Coghlan et al. (2021) agree that weak internet connectivity affects the effective use of invigilation systems, compromising the smooth running of non-venue-based assessments and heightening the risk of cheating. Arguably, the participants in this study could have had older devices, as many came from disadvantaged socio-economic backgrounds, meaning the software might not function optimally. Dawson (2020) supports the idea that technical challenges can compromise academic integrity and thereby foster academic dishonesty.

7. Conclusion

This study explored undergraduate mathematics education students' perceptions of the use of OPSs and the challenges of their adoption in an ODeL environment. The respondents highlighted both positive and negative issues: The former related to the usefulness and usability of OPSs, while the latter pertained to setbacks and potential technical problems.

First, this study revealed that the participants accepted and supported the use of OPSs during THEs, as the technology appeared to be both useful and usable. For them, the system was more effective than face-to-face invigilation during venue-based examinations. They expressed satisfaction with the use of OPSs, as it prevents students from cheating by detecting any movement and inappropriate activity during the invigilation. This is especially effective when students are in a safe and private environment during examinations. Second, the usability of OPSs included access to the app and ease of use when taking photos and scanning examination answer scripts. This usability is sustainable if students are trained and continue to receive technical support during THEs. Lastly, setbacks included erratic internet connectivity, loadshedding, and outdated devices due to students' disadvantaged socio-economic backgrounds. The participants voiced their dismay at technical problems that hampered their academic achievement and created opportunities for cheating by opportunistic

students. If these technical problems are not identified and addressed in advance, they will impede the effective use of OPSs during THEs, and students' marks will be affected. Students should ensure that they take their exams in a venue with an uninterrupted power supply and consistent internet connectivity, and they should upgrade the devices they use to give themselves the best chance of achieving academically.

7.1 Limitations and recommendations

This study was limited to the views of mathematics education undergraduate students at Unisa who took THEs using an OPS. It did not focus on the lecturers' perceptions of the challenges students experience in this context. The findings are not generalisable to the whole population of students who use OPSs during THEs in an ODeL environment. Further studies can be conducted with larger samples (quantitative studies) involving undergraduate mathematics education students and students from other disciplines in order to generalise the results, as this study used a small sample size.

8. Declarations

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Conflicts of Interest: The author declares no conflict of interest.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request. Access will be granted to researchers who meet the criteria for data sharing established by the institutional review board or ethics committee.

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