Namibian Teachers’ Behavioural Intentions on Students’ Mathematics Learning Using Their Own Devices

Cloneria Nyambali Jatileni*, Sari Havu-Nuutinen, Susanna Pöntinen
University of Eastern Finland, FINLAND

Abstract: Bring your own device (BYOD) policy implementation in schools worldwide has allowed students to learn subjects, including mathematics, using personal mobile devices (PMDs). PMD use has enhanced students’ mathematics enjoyment by bridging the gap between theoretical mathematics concepts and their practical applications, which makes mathematics more meaningful and leads to improved results. Nonetheless, students in Namibian basic education are not authorised to learn with PMDs in school. While students’ PMD use in school remains a topic of debate, there remains a need to investigate its impact on students’ mathematics learning and teachers’ perceptions of BYOD in mathematics classrooms. This study evaluated the perceptions and intentions of 209 Namibian mathematics teachers from the Omusati and Khomas regions regarding students' mathematics learning using PMDs in schools. Data were collected through an online survey. A structural equation model revealed teachers' positive intentions towards students’ use of PMDs through BYOD in learning mathematics in school. Perceived usefulness (PU), perceived ease of use (PEoU), and price value (PV) factors directly affected the teachers’ behavioural intentions (BI) towards students learning mathematics through BYOD. PEoU significantly affected teachers’ PU, and PV significantly affected teachers’ PEoU and PU. PU significantly mediated the relationship between PEoU and teachers’ intentions. PV significantly indirectly affected teachers’ intentions through PU. PEoU non-significantly mediated the PV and intention relationship. Practical implications are discussed, and recommendations are offered for the Namibian Ministry of Education, Arts and Culture and teacher training institutions.

Keywords: Behavioural intention, mathematics, perceived ease of use, perceived usefulness, price value.


Introduction

The adoption of BYOD in education is an emerging trend, enabling students to use their mobile devices for learning (Sánchez et al., 2020). Emerging educational technologies are promising innovations with the potential to positively impact teaching and learning, gradually becoming part of school cultures (Owan et al., 2022). However, there is no common definition of BYOD among researchers. Some define BYOD as a learning programme, concept, initiative, trend, policy, scheme, project, approach, or method (Aggarwal, 2018; Arijanova, 2022; Demchenko et al., 2022; French et al., 2015; Keane & Keane, 2022; Mawere et al., 2022; Sánchez et al., 2020; Tsui & Mok, 2019). Although researchers have combined different terms to define BYOD, their definitions generally share a common meaning (Sánchez et al., 2020). In this study, BYOD in a school context refers to students using their laptops, tablets, and smartphones for mathematics learning in the classroom and on school premises (Arijanova, 2022; Siyam et al., 2022).

Students’ use of personal mobile devices (PMDs) under BYOD is a globally debated topic in schools (Mawere et al., 2022). Ongoing debates involve educational stakeholders (students, teachers, parents, and policymakers) on the relevance and feasibility of PMD-assisted learning in schools (Jamaat et al., 2016; Parsons & Adhikari, 2016). While some researchers acknowledge the challenges of implementing BYOD in schools, others emphasise its educational benefits.

BYOD in primary education fosters student engagement, enthusiasm, and learning excitement while also promoting creative development in younger students (Demchenko et al., 2022; Mawere et al., 2022). Arijanova (2022) predicted that PMDs and BYOD policies would significantly influence the future of education. The incorporation of BYOD-related subjects and curricula has yielded positive outcomes, particularly in English language, geography, and biology education.
Diverse PMDs in the classroom can pose challenges for teachers in BYOD implementation. Teachers may struggle with unfamiliar devices, hindering their ability to assist students during lessons. Additionally, cybersecurity is a school concern (French et al., 2015). Critics argue that BYOD fosters a digital divide among students and may disrupt learning, especially the use of smartphones (Johnson, 2019; Mawere et al., 2022). Consequently, some countries have banned students’ use of PMDs in schools (Beneito & Vicente-Chirivella, 2020; Dempsey et al., 2019). However, BYOD policies could be implemented in schools to combat the ever-changing and emerging nature of PMDst to ensure uniformity. In this study, BYOD policies refer to the set of rules that regulate students’ use of PMDs for mathematics learning in schools (Arifjanova, 2022).

The Namibian Ministry of Education has not authorised students’ use of PMDs in schools for learning because of negative beliefs about PMDs (Osakwe et al., 2017). However, the importance of properly integrating students’ PMDs into learning cannot be overemphasised, and authorities should consider their advantages and disadvantages (Clark et al., 2021). However, with proper training and awareness for both students and teachers, BYOD implementation can enhance education and foster students’ achievement (French et al., 2015).

Aggarwal (2018) recommended assessing potential challenges before adopting emerging technologies in schools. Moreover, schools should first gain the approval of key educational stakeholders, such as teachers, students and policymakers before introducing BYOD for mathematics learning (Kaisara et al., 2022). Teachers and students, as end users, are pivotal to BYOD implementation. Furthermore, in their role as policy implementers, teachers hold particular significance, as they not only facilitate learning but can also pinpoint BYOD implementation challenges. Hence, their intentions are crucial in enabling students to learn mathematics with PMDs in school.

This study explores teachers’ perceptions of students using PMDs to learn mathematics through the BYOD policy in schools, contributing to the ongoing debate on BYOD in education. We employ the technology acceptance model (TAM) to investigate teachers’ intentions and opinions. TAM is a well-established framework for assessing teachers’ technology adoption, including BYOD (Mawere et al., 2022; Saidu & Al Mamun, 2022). First, we evaluate how PU, PEoU, and PV directly impact teachers’ intentions towards students’ use of PMDs through BYOD to learn mathematics in schools. Second, we analyse the direct effects of PEoI on PU and PV on PU and PEoI. Third, we assess the indirect effects of teachers’ PEoU and PU on their BI. Our study combines an analysis of direct and mediated effects to comprehensively capture the relevant methodological and theoretical aspects. This ambitious approach aims to provide a holistic understanding of the bigger picture related to BYOD.

**Literature Review**

*Bring Your Own Device*

Previous research on BYOD implementation in schools primarily focused on students’ intentions, with less emphasis on teachers’ perspectives (Aggarwal, 2018; Clark et al., 2021; Hakami, 2020; Masilo et al., 2021; Mozelius et al., 2020; Nuhoglu Kibar et al., 2020; Sánchez et al., 2020; Siyam et al., 2022; Tinnaz & Lee, 2019). These studies discussed the advantages and challenges of BYOD use in education and its impact on subjects other than mathematics. Mawere et al., (2022) and Siyam et al. (2022) utilised the TAM to examine teachers’ perceptions and intentions towards PMD use in schools in the Global South and BYOD use in the classroom, respectively. However, these studies did not specifically focus on the use of BYOD for mathematics learning. Other studies have employed different theoretical approaches to understand teachers’ opinions of BYOD in education. Kaisara et al. (2022) noted a scarcity of literature on PMD use in education, particularly from an African perspective. Further research is required to address limitations and extend the understanding of the PMDs’ effects on mathematics teaching and learning (Fabian & Topping, 2019), and there is a dearth of research on BYOD from the perspective of educational stakeholders (Tsui & Mok, 2019).

Students who use PMDs in educational settings have demonstrated the value that BYOD adds to their learning (French et al., 2015). Furthermore, Poláková and Klímová (2019) showed that PMD use has a positive effect on students’ achievement and lesson enjoyment. Additionally, Suprianto et al. (2019) reported a significant increase in the autonomous learning outcomes of students who learn mathematics using PMDs. BYOD also facilitates easy contact between students and teachers, leading to improvements in students’ algebraic thinking skills (Rudyanto et al., 2019). Although prolonged PMD use was associated with a significant increase in adolescent academic performance, it significantly decreased their achievement scores in mathematics and English (Liu et al., 2020).

The BYOD implementation in schools has been criticised by teachers, parents, policymakers, and students (Tsui & Mok, 2019). In addition, teachers have argued that BYOD is unnecessary in schools and that some students do not own or that
their parents cannot afford PMDs (Alalwan et al., 2020). Further, they claimed that students do not fully take responsibility for the upkeep of their PMDs (Alalwan et al., 2020) and that many parents oppose BYOD policies that make PMD use mandatory in learning (Alalwan et al., 2020). Parents have described BYOD as a source of distraction, which makes parental intervention increasingly difficult and ultimately increases the burden of parenting (Page Jeffery, 2022). Similarly, students and parents share worries about students learning with PMDs in school, specifically that it may replace some important pen-and-paper learning methods (Tsui & Mok, 2019). However, despite health concerns related to students’ prolonged use of PMDs, many parents believe that PMDs provide easier access to learning resources and can enhance learning motivation (Tsui & Mok, 2019).

The literature review recommends studies on teachers’ opinions, with a specific focus on BYOD implementation in schools, particularly in developing countries like Namibia. None of the reviewed research used the TAM to comprehend basic education mathematics teachers’ intentions related to students’ mathematics learning using PMDs through BYOD. This research gap highlights the need to examine teachers’ intentions regarding BYOD implementation in basic education. Hence, to address this gap, our study utilises the TAM to explore teachers’ intentions towards the adoption of BYOD for mathematics in the context of basic education in Namibia.

Technology Acceptance Model

This study uses the TAM because it incorporates a limited number of factors, which enhances comprehension of findings, and has high predictive capability regarding the acceptance of educational technology (Saidu & Al Mamun, 2022; Salloum et al., 2019). TAM is an information systems theory that explains technology acceptance by individuals (McCord, 2007). Davis (1989) developed the TAM from the theory of reasoned action limitations, which only provided a psychological perspective on human behaviour and lacked the information systems aspect (Davis, 1993). The TAM extended into three models (Chuttur, 2009), which elucidate the practices underlying technology acceptance, predict users’ behaviour, and provide a theoretical explanation for the success of technology implementation (Davis, 1989, 1993; McCord, 2007). Practically, the TAM informs practitioners of the measures to take before implementing technological systems, such as BYOD in the mathematics classroom (Durodolu, 2016).

In this study, the TAM provides the foundation for ascertaining teachers’ perceived impact of PMD use on students’ mathematics learning as well as the teachers’ intentions related to BYOD in schools. TAM predicts technology acceptance based on users’ intentions, which are influenced by the perceived usefulness and ease of use of the technology (McCord, 2007). Our study evaluates the main TAM factors—behavioural intentions, perceived usefulness, and perceived ease of use—examining teachers’ perceptions of BYOD’s usefulness, ease of use for their students, and provision and availability of PMDs to students.

Although the TAM is a strong model for predicting technology acceptance, Granić and Marangunić (2019) proposed adding other factors to the original TAM constructs, which explains why there are three TAM models. In this study, we added PV to the TAM factors to account for PMD availability and provision to students in the Namibian context. The TAM is often combined with the unified theory of acceptance and use of technology constructs to form a unified model (Chatterjee et al., 2020). Adding PV to the TAM in our study can theoretically contribute to the literature in a distinct way.

The TAM includes two outcome factors: BI and actual use (Davis, 1989). BI refers to the willingness to attain the target behaviour (Chatterjee et al., 2020). Based on the TAM, teachers’ intentions to accept educational technology are determined by their PU and PEoU (Aggarwal, 2018). Teachers’ positive intentions towards students learning mathematics with PMDs through BYOD in school are likely to lead to supportive behaviour. BI is the dependent variable in this study and is influenced by the independent variables, in alignment with our first objective.

**PU** is the degree to which a person believes that technology can enhance their job performance or improve their learning (Davis, 1989; Mailizar et al., 2021). PU affects teachers’ BI both directly and indirectly (Camadan et al., 2018; Mailizar et al., 2021). A high PU system is one in which participants believe in a positive relationship between use and performance (Davis, 1989). If teachers believe that BYOD can improve mathematics teaching, enhance learning, and improve student performance, then they would have a high positive PU towards PMD use through BYOD in school (Aggarwal, 2018), which would positively affect their BI.

**PEoU** is the extent to which an individual believes that using a certain technology requires less physical and mental effort (Davis, 1989; Saidu & Al Mamun, 2022). PEoU directly affects teachers’ PU and their BI (Saidu & Al Mamun, 2022). Users prefer easier-to-use applications (Davis, 1989). If teachers perceive that learning mathematics with PMDs requires less effort for students, then they are more likely to accept BYOD. Thus, PEoU affects teachers’ PU and BI towards BYOD for mathematics learning in school, and vice versa.

**Price or cost value (PV)** refers to the monetary value of a product or service—that is, whether it is worthwhile to spend money on a product or service (Bower et al., 2020). Teachers are not responsible for purchasing PMDs. This factor was only used to examine their perceptions of PMD provision by parents, the Ministry of Education, and students. If teachers believe that educational stakeholders would provide students with PMDs, then teachers’ perceived PV would significantly affect their intentions towards BYOD for mathematics learning in school (Chatterjee et al., 2020).
The mediated effect helps researchers test theoretical models with multiple linkages between factors (Hayes, 2009). To achieve our third objective, we examined how PU and PEoU mediate the effects of PV on teachers' BI. PEoU directly affects teachers' PU and indirectly influences their BI (Davis, 1989; Saidu & Al Mamun, 2022). Two mediators, PEoU and PU, influence intention to use technology (Davis, 1989). Our study employed a two-path analysis to assess the mediating effect of PU and PEoU on the relationship between PV and BI. As PU and PEoU are mediators according to the TAM, we assess their mediating role in the link between PV and BI. The study is guided by five research questions (RQs), on which we base nine hypotheses. Figure 1 shows the proposed study model with the hypotheses and paths.

RQ1: How do teachers' PU, PEoU and PV directly relate to their BI towards students' learning of mathematics through BYOD in school?

H1: PU has a statistically significant positive direct effect on teachers' BI.
H2: PEoU has a statistically significant positive direct effect on teachers' BI.
H3: PV has a statistically significant positive direct effect on teachers' BI.

RQ2: How does teachers' PEoU directly relate to their PU towards students' learning of mathematics through BYOD in school?

H4: PEoU has a statistically significant, positive effect on teachers' PU.

RQ3: How does PV directly affect teachers' PEoU and PU towards students' learning of mathematics through BYOD in school?

H5: PV has a statistically significant direct positive effect on teachers' PEoU.
H6: PV has a statistically significant direct positive effect on teachers' PU.

RQ4: What is the mediating role of teachers' PU on the relationships between PEoU and BI and between PV and BI towards students' learning of mathematics through BYOD in school?

H7: PU statistically and significantly mediates the PEoU effect on teachers' BI.
H8: PU statistically and significantly mediates the PV effect on teachers' BI.

RQ5: What is the mediating role of PEoU on the relationship between teachers' PV and BI towards students' learning of mathematics through BYOD in school?

H9: PEoU statistically and significantly mediates the PV effect on teachers' BI.

Methodology

Instruments

We used a close-ended self-administered online survey to gather data from teachers on their intentions towards students' learning of mathematics with PMDs in school. Given the novelty of the topic under study, we could not find an exact survey tool with the same focus as ours during instrument development. However, our study's aims and objectives closely align with those of prior studies (Chatterjee et al., 2020; Hoi & Mu, 2021; Xu & Zhu, 2020) and their survey tools. We conducted a review of their survey instruments, considering our study's desired population, context, and objectives. To
validate our own survey, we adopted existing survey items that assessed items similar to those in our study. Additionally, we conducted a pilot study with 50 teachers to evaluate their BYOD knowledge and perceptions and to assess the survey tool’s reliability, following Lowe’s (2019) approach. Validity was established through factor analysis, ensuring that the items loaded appropriately onto their respective components and assessing item correlations. We also had experts in the field review the tool to confirm that it covered the theoretical construct being measured. Items with too low or too high correlations, those that did not fit into any factor, and those that loaded on multiple components were removed from the final tool. The final survey contained 12 questions. The first five questions gathered demographic data on the participants, including gender, age, teaching experience, qualification, and region. The other 7 questions consisted of 38 items, which were grouped into seven factors. Four of these factors (BI, PU, PEOU, and PV) formed the basis of this study. The other two factors were not included in this paper. The survey used a five-point Likert scale, with which participants could express how much they agreed or disagreed with the survey statements (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). To avoid partial responses and missing data, responses to all items on the survey tool were mandatory (Décieux et al., 2015).

**Data Collection**

The study used volunteer purposeful sampling of grade 4–12 mathematics teachers from the Omusati and Khomas regions. Purposive sampling was used to improve the rigour of this study and the trustworthiness of the data and results by producing a match between the sample, aims, and study objectives (Campbell et al., 2020). The participating teachers did not experience BYOD in their schools. However, the researcher generally introduced the BYOD concept on the survey’s front page to ensure that the participants shared a common understanding. Additionally, participants were instructed to respond honestly. Some participants requested a further explanation of the BYOD for mathematics learning concepts, to which the researcher provided a general explanation without discussing its pros and cons. Although the survey was online and self-administered, not all schools in the participating regions had active school websites to easily find the contact details of mathematics teachers. To collect data from only mathematics teachers in the two regions, the researcher moved from one school to another, presenting the research idea, collecting the written informed consent forms, and sharing the survey link with the intended participants. In cases where teachers did not have mobile devices to access the survey, the researcher had extra devices for them to use. Some schools, especially in rural areas, did not have a Wi-Fi internet connection. To ensure the participation of mathematics teachers from those schools, the researcher used an internet pocket device router to supply a Wi-Fi connection. Data were collected between March and June 2022.

**Participants**

A total of 209 grade 4–12 mathematics teachers, 40% males and 60% females, from both the Omusati and Khomas regions completed the online survey. These regions are among those with the highest teacher populations in the country. The Khomas region represents urban schoolteachers, while the Omusati region represents rural schoolteachers. Table 1 shows the participants’ demographic information based on region and gender. Of the teachers, 60% (48 males and 76 females) were from the Omusati region, while 41% (36 males and 49 females) were from the Khomas region. Moreover, the table shows the participants’ academic qualifications in education. Most (58%) of the participants had a bachelor’s degree, 16% had master’s degrees, 13% had a diploma, and 8% had a doctorate. A small minority (5%) of the mathematics teachers had no qualifications in education. The table further presents the participants’ age groups. More than half (51%) of the teachers were between the ages of 22 and 30, 28% were between 31 and 40, 13% were between 41 and 50, and 9% were between 51 and 60. Table 1 indicates the participants’ years of teaching experience. The largest proportion, 30%, were novice teachers, 24% had taught for about three years, and 23% had taught for 10 years or more. Sixteen percent of teachers had taught between 4 and 6 years, while 7% had 7 to 9 years of teaching experience.

The number of teacher participants provided a limited representation of approximately 15,000 mathematics teachers nationwide, and their perceptions might not entirely represent the opinions of all Namibian mathematics teachers. However, the sample was representative of the Namibian teacher population (Ministry of Education, Arts and Culture Republic of Namibia, 2022).
Table 1. Participants’ Demographic Information

<table>
<thead>
<tr>
<th>Gender</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omusati</td>
<td>48</td>
<td>76</td>
<td>124</td>
</tr>
<tr>
<td>Khomas</td>
<td>36</td>
<td>49</td>
<td>85</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>125</td>
<td>209</td>
</tr>
<tr>
<td>Qualification in education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diploma</td>
<td>14</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>46</td>
<td>76</td>
<td>122</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>12</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>Doctorate (PhD)</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Unqualified</td>
<td>4</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>125</td>
<td>209</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22–30</td>
<td>30</td>
<td>76</td>
<td>106</td>
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<tr>
<td>31–40</td>
<td>23</td>
<td>35</td>
<td>58</td>
</tr>
<tr>
<td>41–50</td>
<td>22</td>
<td>5</td>
<td>27</td>
</tr>
<tr>
<td>51–60</td>
<td>9</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>125</td>
<td>209</td>
</tr>
<tr>
<td>Teaching experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1 year</td>
<td>21</td>
<td>41</td>
<td>62</td>
</tr>
<tr>
<td>1–3 years</td>
<td>20</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>4–6 years</td>
<td>7</td>
<td>27</td>
<td>34</td>
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<tr>
<td>7–9 years</td>
<td>5</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>More than 10 years</td>
<td>31</td>
<td>18</td>
<td>49</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>125</td>
<td>209</td>
</tr>
</tbody>
</table>

Data Analysis

The dataset was extracted from the Webropol survey system for analysis using the Stata Package for the Social Sciences (SPSS,27) and IBM Amos 27. Teachers’ perceptions and intentions towards students’ learning of mathematics with PMDs through BYOD in school were examined through a series of quantitative analyses. Principal component analysis (PCA), correlation tests, reliability tests, confirmatory factor analysis, and structural equation modelling (SEM) analyses were performed to establish the relationship between the components and their items. PCA extraction with varimax, suppressing small coefficients, sorting them by size, and accepting absolute values >.50, was applied to the items. The PCA generated six components with eigenvalues >1, which were retained based on the Kaiser criterion; the rest were deleted (Courtney, 2013). Four of the six retained factors were used in this study (see Table 2), while the rest were used in a different study. Eight items loaded on the first component. Five of these items were grouped under behavioural action, while the other three were grouped under BI factors on the survey tool. In the PCA, these eight items were arranged as one component, and the items that strongly loaded on this component were grouped under BI on the survey. The strongly loaded factor items determine the factor’s name (Strickland, 2003). Our first component was BI. Seven items were loaded on the second component, PU. Three items loaded on the third component, PV, while two items loaded on the fourth component, PEoU. Table 1 presents the rotated component matrix.

Table 2. Rotated Component Matrix

<table>
<thead>
<tr>
<th>Component loading</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B11: I think pupils’ results will improve if they use their own mobile devices while learning math in school</td>
<td>.836</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B12: I think it would be a good strategy for pupils to use their own mobile devices while learning math</td>
<td>.768</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B13: I think it would be a positive idea for pupils to use their own mobile devices for learning in school</td>
<td>.739</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B14: If allowed, I intend to recommend that my colleagues encourage their pupils to use their own devices to learn math in the future</td>
<td>.723</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B15: Assuming all pupils will have access to the internet in school, I intend to allow them to use it to learn math</td>
<td>.712</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B16: I believe it would be advantageous for Namibian pupils to use their own mobile devices to learn math</td>
<td>.709</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B17: If allowed, I intend to increase pupils’ use of their own mobile devices to learn math in school</td>
<td>.676</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Continued

<table>
<thead>
<tr>
<th>Component</th>
<th>No. of items</th>
<th>Cronbach's alpha</th>
<th>Composite reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioural intention</td>
<td>8</td>
<td>.955</td>
<td>.954</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>7</td>
<td>.948</td>
<td>.949</td>
</tr>
<tr>
<td>Price value</td>
<td>3</td>
<td>.877</td>
<td>.878</td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>2</td>
<td>.858</td>
<td>.954</td>
</tr>
</tbody>
</table>

Extraction method: Principal component analysis
Rotation method: Varimax with Kaiser normalisation
*Rotation converged in six iterations

The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was very good (.94), and Bartlett’s Test of Sphericity was significant (p = .000). Therefore, the sample size of 209 was adequate, above the recommended > .50 KMO (Dogbegah et al., 2011). Table 3 presents the number of items, Cronbach’s alpha of each component, and composite reliability. The components showed excellent internal consistency, with reliability values of Cronbach’s alpha and composite reliability > .70 (Basto & Pereira, 2012; Tegor et al., 2023).

We computed items under each component to form a construct. The inter-construct correlation assesses the extent to which the scores of one construct are related to the scores of the other (Piedmont, 2014). Here, the inter-construct correlation was positive and significant (Table 4). All the constructs positively and significantly correlated with each other (p < .000). The strongest positive observed correlation coefficient (r = .825) was between BI and PU. PU was positively and significantly correlated with PV (r = .671), while BI and PV were positively and significantly correlated (r = .670). PEoU was positively and significantly correlated with PU (r = .522), and PEoU and BI were also positively correlated (r = .533). PV and PEoU were weakly positively and significantly correlated (r = .385). The correlation coefficients of our constructs ranged between the recommended values (r = .4–.8) for inter-construct correlations (Gogtay & Thatte, 2017).

Table 4. Pearson Correlations between the Factors

<table>
<thead>
<tr>
<th>PU</th>
<th>BI</th>
<th>PV</th>
<th>PEoU</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU</td>
<td>1</td>
<td>.825**</td>
<td>.671**</td>
</tr>
<tr>
<td>BI</td>
<td>.825**</td>
<td>1</td>
<td>.670**</td>
</tr>
<tr>
<td>PV</td>
<td>.671**</td>
<td>.670**</td>
<td>1</td>
</tr>
<tr>
<td>PEoU</td>
<td>.522**</td>
<td>.533**</td>
<td>.385**</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the .01 level (two-tailed).
A confirmatory factor analysis (CFA) confirmed the hypothesis of the relationship between the observed variables and the causal latent constructs. CFA tested the factorial validity of the theoretical constructs and verified the items and factor structure (Byrne, 2016). Table 5 presents the CFA assessment of the measurement model. High loadings confirmed that the items were very well explained by the latent factors. Further, CFA confirmed the construct validity and the model measurements, with all items having statistically significant parameters as well as a good model fit: $x^2/df = 1.813 (< 5.0)$, $p = .000 < .001$, SRMR = .0285 (< .05), RMSEA = .063 (< .08), GFI = .896 (> .80), TLI = .963 (> .90) and CFI = .972 (> .90) (Byrne, 2016; Doll et al., 1995; Jarwa et al., 2021; Li et al., 2020). Our CFA model meets established thresholds. The CFI produced a GFI of 0.896, falling within the range of .80–.89, indicating an acceptable good fit, although it’s important to note that a GFI >0.90 is considered an excellent fit (Doll et al., 1995; Hong et al., 2023; Koçak & Göksu, 2023; Qin et al., 2023; Zong et al., 2023). This outcome suggests that our CFA model has produced good results, allowing us to proceed with the SEM analysis confidently.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item</th>
<th>Unstandardised estimate</th>
<th>Standardised estimate</th>
<th>t-value (C.R)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioural intention</td>
<td>BI1</td>
<td>.942</td>
<td>.809</td>
<td>16.522</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>BI2</td>
<td>1.000</td>
<td>.873</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>BI3</td>
<td>.784</td>
<td>.713</td>
<td>14.807</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>BI4</td>
<td>.991</td>
<td>.865</td>
<td>15.985</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>BI5</td>
<td>.945</td>
<td>.898</td>
<td>17.255</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>BI6</td>
<td>.953</td>
<td>.824</td>
<td>15.977</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>BI7</td>
<td>1.017</td>
<td>.867</td>
<td>21.615</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>BI8</td>
<td>.948</td>
<td>.868</td>
<td>16.197</td>
<td>***</td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>PU1</td>
<td>.898</td>
<td>.787</td>
<td>15.761</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PU2</td>
<td>1.000</td>
<td>.888</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>PU3</td>
<td>.933</td>
<td>.837</td>
<td>17.177</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PU4</td>
<td>.950</td>
<td>.824</td>
<td>19.126</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PU5</td>
<td>.945</td>
<td>.864</td>
<td>15.789</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PU6</td>
<td>.946</td>
<td>.878</td>
<td>15.945</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PU7</td>
<td>.863</td>
<td>.851</td>
<td>15.305</td>
<td>***</td>
</tr>
<tr>
<td>Price value</td>
<td>PV1</td>
<td>1.085</td>
<td>.844</td>
<td>13.692</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PV2</td>
<td>1.000</td>
<td>.819</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>PV3</td>
<td>1.152</td>
<td>.857</td>
<td>13.925</td>
<td>***</td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>PEOu1</td>
<td>.678</td>
<td>.747</td>
<td>9.591</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>PEOu2</td>
<td>1.000</td>
<td>1.009</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

***$p < .001$. SEM was used to test the direct and indirect effect of the predictors (PU, PEOu, and PV) on the dependent variable (BI). Further, SEM was used to test the direct effects of PEOu on PU, PV on PU, and PV on PEOu. In the first part of the SEM analysis, we assessed the direct effects of PU, PEOu, and PV on intentions through the model paths b1, b2, and a3, respectively. Next, a multiple mediation analysis was used to assess the indirect effect of the independent variables on the dependent variable through all possible mediators. This analysis tested Venkatesh and Davis’ (2000) assumptions that PU and PEOu fully mediate the effect of external variables on participants’ intentions. We manually separated the specific indirect effects using the syntax-based user-defined estimand function, which defined the different mediation paths within our model (Collier, 2020). The hypothesised mediation paths (see Figure 1) were tested in a multiple model using a bootstrapping approach to assess the significance of the indirect effects at differing levels of the mediator. A total of 500 bootstrap samples were performed with 95% bias-corrected confidence intervals. In the first mediated path, PU was a mediator of the path (a1b1) between the dependent variable PEOu and the outcome BI. In the second mediated path, PU was a mediator of the path (b3b1) between the dependent variable PV and the outcome BI. In the last mediated path, PEOu was a mediator of the path (a2b2) between the dependent variable PV and the outcome BI.

**Results**

This study assessed the direct effect of teachers’ PU, PEOu, and PV on their BI towards students’ learning of mathematics with PMDs in school. The study also evaluated how teachers’ PEOu affects their PU. The direct effect between PV and teachers’ PU and PEOu was also assessed. Further, the study examined the indirect effects of PV and PEOu on BI. The following section addresses the study’s five research questions and nine hypotheses.
Teachers’ Intentions Towards Students’ Learning of Mathematics Through BYOD in School

To investigate the hypothesised relationships between the factors, an SEM path model was constructed. The model (Figure 2) had an acceptable good fit: \( x^2/df = 1.994 \) (< 5.0), \( p = .000 < .001 \), SRMR = .0347 (< .05), RMSEA = .067 (< .08), GFI = .883 (> .80), TLI = .956 (> .90) and CFI = .965 (> .90) (Byrne, 2016; Jarwa et al., 2021). In line with the study’s five research questions, we tested six hypotheses regarding the direct effects of PU, PEoU and PV on teachers’ BI. Three other hypotheses were tested based on the mediated effects of PEoU and PU. Estimates of all the path coefficients are presented in Tables 6 and 7.

Figure 3 shows the factors of the SEM theoretical model and their item’s standardised beta weights. The value .81 above the BI factor indicates the amount of variance of teachers’ intention explained by the predictor variables using standardised regression coefficients (\( R^2 \)) (i.e. the overall \( R^2 \) of the model was .81). In other words, the predictor variables explained 81% of the variance in teachers’ intentions towards students’ learning of mathematics through BYOD in school.

**Perceived Usefulness, Perceived Ease of Use, and Price Value Directly Predict Behavioural Intentions**

In response to RQ1, Table 6 shows that all factors had a positive direct effect on teachers’ BI. PU had a positive and significant direct effect on BI (\( \beta = .715, t = 8.972, p = .000 < .001 \)). Therefore, \( H_1 \) (PU has a statistically significant, positive, and direct effect on teachers’ BI) is accepted. PU was the highest and strongest significant predictor of teachers’ BI towards students’ learning of mathematics through BYOD in school.

PEoU had a significant, positive, and direct effect on teachers’ BI (\( \beta = .092, t = 2.055, p = .040 < .05 \)). Consequently, hypothesis \( H_2 \) (PEoU has a statistically significant positive direct effect on teachers’ BI) is confirmed. However, PEoU was the least significant predictor of teachers’ BI towards students’ learning of mathematics through BYOD in school.

PV had a positive significant direct effect on BI (\( \beta = .165, t = 2.675, p = .007 < .05 \)). Thus, \( H_3 \) (PV has a statistically significant positive direct effect on teachers’ BI) is accepted. PV was the second-most significant predictor of teachers’ BI towards students’ learning of mathematics through BYOD in school.

**Perceived Ease of Use Predicts Perceived Usefulness**

Regarding RQ2, PEoU had a statistically significant positive direct effect on teachers’ PU (\( \beta = .307, t = 4.769, p = .000 < .001 \)). Thus, \( H_4 \) (PEoU has a statistically significant positive direct effect on teachers’ PU) is also accepted.
Price Value Predicts Perceived Ease of Use and Perceived Usefulness

Regarding RQ3, PV had a significant positive direct effect on teachers’ PEoU (β = .436, t = 6.254, p = < .001) and PU (β = .595, t = 8.618, p = < .001). Hence, H₅ (PV has a statistically significant positive direct effect on teachers’ PEoU) is accepted. H₆ (PV has a statistically significant positive direct effect on teachers’ PU) is also accepted. PV had a stronger, more significant, more positive direct effect on teachers’ PU than on their PEoU. The PV of using PMDs had a more positive effect on teachers’ PU and PEoU of mobile devices.

The Mediating Role of Perceived Usefulness

Table 7 presents a summary of the mediation analysis. The mediating effects of PU are in paths (a1b1) and (b3b1). The mediating effect of PEoU on PV and BI is in path (a2b2).

The Mediating Effect of Perceived Ease of Use

Regarding RQ4, Table 7 shows the significant mediating role of PU on the relationship between PEoU and BI (B = .157, t = 3.413, p = .002 < .05). Thus, H₇ (PU statistically and significantly mediates the effect of PEoU on teachers’ BI) is accepted. Relatedly, the results revealed a significant indirect effect of PV on BI through PU (B = .427, t = 5.024, p = .002 < .05). Thus, H₈ (PU statistically and significantly mediates the effect of PV on teachers’ BI) is also accepted.

The Mediating Analysis Summary

Table 7 shows the non-significant mediating role of PEoU on the relationship between PV and BI (B = .40, t = 1.333, p = .121 > .05). Therefore, H₉ (PEoU statistically and significantly mediates the effect of PV on teachers’ BI) is not accepted.

Discussion

The first objective of this study was to assess the direct effects of PU, PEoU and PV on teachers’ BI towards students’ learning of mathematics with PMDs through BYOD in school. The second objective was to examine the direct effects of PEoU on PU and PV on PU and PEoU. The third objective was to assess the indirect effects of PEoU and PV on teachers’ BI. Five research questions and nine hypotheses guided the study using the three basic TAM factors. We examined the structural abilities of five factors in predicting teachers’ BI related to students’ learning of mathematics with PMDs through BYOD in school. Overall, the participating teachers showed a positive high BI towards students’ learning of mathematics with PMDs in school. This could be attributed to the participating teachers’ support for BYOD adoption in Namibian basic education. Consistent with previous studies (Davis, 1989; Livas et al., 2019; Siyam et al., 2022), teachers with positive BI towards a technology are more likely to persevere in their endeavours to integrate that technology into their classroom practices.

Table 7. Mediation Analysis Summary

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Relationship (paths)</th>
<th>Direct effect</th>
<th>Indirect effect</th>
<th>Confidence interval</th>
<th>P-value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower bound</td>
<td>Upper bound</td>
<td></td>
</tr>
<tr>
<td>H7</td>
<td>PEoU → PU → BI (a1b1)</td>
<td>.066</td>
<td>.157</td>
<td>.079</td>
<td>.276</td>
<td>.002</td>
</tr>
<tr>
<td>H8</td>
<td>PV → PU → BI (b3b1)</td>
<td>.165</td>
<td>.427</td>
<td>.286</td>
<td>.618</td>
<td>.002</td>
</tr>
<tr>
<td>H9</td>
<td>PV → PEoU → BI (a2b2)</td>
<td>.165</td>
<td>.040</td>
<td>- .007</td>
<td>.112</td>
<td>.121</td>
</tr>
</tbody>
</table>

Note. PU = perceived usefulness, PV = price value, PEoU = perceived ease of use, BI = Behavioural Intention; ***p < .001, **p < .05.
In this study, PU predicted teachers’ BI with a significantly high beta weight. These findings agree with TAM’s original theoretical framework, which states that higher levels of PU lead to higher BI. Our findings echo those of Siyam et al. (2022), who found that PU had a statistically significant positive effect on teachers’ BI towards BYOD in the classroom. Similarly, Zhao (2017) reported that PU had a statistically significant positive effect on teachers’ BI towards BYOD for English teaching and learning. These findings may serve as a consistent indication that teachers consider students’ PMDs to be essential and useful learning tools. However, our findings disagree with those of Mailizar et al. (2021), who found that PU had an insignificant negative effect on teachers’ BI towards e-learning use in a mathematics classroom. The results of Mailizar et al. (2021), Siyam et al. (2022), and Zhao (2017) prove the appropriateness of the TAM theoretical framework for BYOD in a school study context. BYOD implementation in school benefits not only the students and the school but also the teachers (Mawere et al., 2022). Thus, if teachers believe that students’ use of PMDs to learn mathematics through BYOD in school will make their teaching work easier while producing the desired results, then teachers may consider BYOD useful for education.

Some schools implement BYOD because it can bridge the digital divide, so students have access to PMDs both inside and outside school (Mawere et al., 2022). The digital divide among students is related to their economic status, as some families cannot afford the cost of PMDs, despite their usefulness for learning. In many schools in developing countries, there are inadequate PMDs to cater to all students at the same time, and the few available devices are often used to train students in information communication technology use and not for pedagogical purposes, such as learning mathematics (Mawere et al., 2022). BYOD implementation allows all students access to mobile devices. Students who cannot afford PMDs can use school-owned devices, while those who can afford PMDs are allowed to use them in school. In our study, the costs of PMDs and their availability were examined based on the PV factor. PV had a positive significant effect on BI. This finding differs from (Chatterjee et al., 2020), who did not find support for a path between PV and BI. Our results further contradict those of Molina-Castillo et al. (2020), who reported that PV had a negative, insignificant effect on participants’ BI. The findings of Molina-Castillo et al. (2020) and Chatterjee et al. (2020) imply that PV is not a significant predictor of BI. The discrepancies in the findings may be attributed to the economic traditions of educational policy and cultural norms regarding the provision of learning materials to students. In some countries, school supplies are traditionally provided by parents, the government, or both. In other countries, teachers may need to request the provision of learning materials from the government or parents. The ease or difficulty of obtaining learning materials can influence how the teachers’ PV factor relates to their BI on students’ PMDs as learning materials. These economic and cultural factors can influence how participants respond to research questions and approach specific topics, affecting resource availability. Notably, Molina-Castillo et al. (2020) and Chatterjee et al. (2020) did not delve much into these factors in their studies.

Further, the direct effect of PV on PU and PEoU in this study suggests that the participating teachers are willing to facilitate students’ learning of mathematics with PMDs through BYOD in school because they consider it useful and easy. However, their PU and PEoU of PMDs for mathematics learning are only valid if the provision of PMDs to students is feasible.

PEoU had a positive, significant impact on teachers’ BI in our study. This result is consistent with Zhao (2017), who also reported that PEoU had a significant positive effect on teachers’ BI towards BYOD for English teaching and learning in school. As in Zhao’s (2017) and Chatterjee et al.’s (2020) studies, the teachers in our study felt that BYOD was useful and easy to use, which resulted in a higher intention to adopt BYOD for mathematics learning. However, our results contradict those of Mailizar et al. (2021), who found that PEoU was a non-significant predictor of teachers’ BI towards e-learning use in mathematics teaching.

PEoU was the least significant predictor of teachers’ intentions in this study, and its unusually low effect on BI can be attributed to three reasons. First, this study was undertaken during a world crisis, when most schools and teachers in Namibia were dealing with the COVID-19 pandemic and its aftermath. In such times of crisis, lower levels of technology acceptance may be linked to higher levels of BI (Kaisara et al., 2022). Hence, teachers might have found it difficult to recognise how easy it would be for students to learn mathematics with PMDs based on what was happening in schools at that time. Second, teachers might consider students to be heterogeneous, as some students may be more prepared than others to learn using PMDs. Third, the participants could believe that a technology or system is useful while also believing that it is difficult to use (Davis, 1989). In such cases, the performance benefits of adopting BYOD in schools for mathematics might be outweighed by its implementation requirements (Davis, 1989). Additionally, we found that PEoU had a direct effect on PU. This finding is similar to those of Siyam et al. (2022) and further validates the TAM assumption that PEoU is a direct predictor of PU (Davis, 1989).

Based on the mediation results, we drew some conclusions on the mediating roles of PU and PEoU. First, the influence of PEoU on BI flows through PU, confirming the TAM assumption that PEoU indirectly influences BI through PU (Davis, 1989). PU partially mediated the relationship between PEoU and BI. Both the mediated and unmediated paths between PEoU and BI were significant in this study. These findings concur with those of Hur et al. (2015), who found that PEoU indirectly influenced teachers’ intentions to use mobile devices for teaching purposes. Partial mediation was also confirmed, as the links between PEoU and PU (the mediator) and the path between PU (the mediator) and BI were all significant in this study. This implies that the participating teachers intend to allow students to learn mathematics with
PMDs in school because they perceived it as both easy and useful. Second, the influence of PV on BI only partially flowed through PU. This suggests that the participants intend to allow students to learn mathematics with PMDs in school if the provision was based on educational stakeholders’ perceptions of their usefulness to mathematics learning. Third, the mediating role of PEoU in the relationship between PV and BI was insignificant. Therefore, the effect of PV on BI was significant only in the absence of the mediator (PEoU). This indicates that the participating teachers’ intent to allow students to learn mathematics with PMDs in school was based on the availability of PMDs to students but not only when they believed they were easy for students to use.

Conclusion

This study’s main outcome is the finding that teachers view students’ learning of mathematics with PMDs as useful and easy. Teachers support BYOD implementation at the basic educational levels for mathematics learning with a moderately high BI. This reflects teachers’ commitment to facilitating students’ learning of mathematics with PMDs through the BYOD policy in school if the devices are made available. However, teachers do not perceive the implementation of BYOD for mathematics learning in schools to be simple. The findings of this study add to TAM’s predictive abilities and support its assumption that PU and PEoU are significant direct predictors of BI. Additionally, this study confirms that PEoU is a direct predictor of PU and an indirect predictor of BI through PU. These results further confirm the unified theory of acceptance and use of technology model’s assumption that PV predicts BI. This study contributes to the literature by demonstrating the mediating roles of PU and PEoU and the direct effects of PV on PU and PEoU.

The study has practical implications. It is not sufficient that teachers perceive BYOD implementation for mathematics in school learning to be useful if supplying PMDs is a challenge. Difficulties in the supply of mobile devices by parents and the Ministry of Education, Arts and Culture could contribute to teachers’ lower PEoU. The Ministry of Education, Arts and Culture should first consider the usefulness of PMDs in mathematics learning and, together with parents, supply PMDs to students. Furthermore, teachers should be trained to facilitate students’ learning of mathematics with PMDs so that they will not consider BYOD for mathematics learning to be overly difficult. For student teachers, PMD use in mathematics classrooms can be integrated into the teacher training curriculum. For in-service teachers, such training could be offered as part of ongoing professional development programmes. Finally, the Ministry of Education, Arts and Culture should develop a BYOD policy that fits the Namibian context to help teachers implement BYOD in schools.

Recommendations

The recommendations made herein are in line with the study results and limitations. Future studies should consider how PEoU and PU influence teachers’ attitudes and, consequently, their intentions. PEoU in this study had a positive but least effect on intentions. Future studies may examine the efforts and risks that teachers associate with BYOD implementation in schools. The PEoU factor had a few items. Future research may consider increasing the number of items in PEoU to provide a more meaningful explanation of its factor structure. Future studies could examine BYOD acceptance and intentions of other educational stakeholders, such as parents and educational policymakers, to better understand its implementation in schools.

Limitations

The study has both theoretical and practical limitations. Attitude is one of the main determinants of intention. However, this study did not examine teachers’ attitudes towards students’ learning of mathematics through BYOD in school. Moreover, we found a low PEoU, implying that teachers perceive BYOD for mathematics to be difficult to implement. However, the types of difficulties were not clarified in this study. This study was only limited to Namibian mathematics teachers. Although PEoU was one of the examined TAM main factors and had good Cronbach’s alpha and composite reliability in this study, having a few items in it may have limited the full interpretation of the PEoU factor structure in our study results.

Ethics Statement

Permission to undertake this study was granted by the Executive Director of the Ministry of Education, Arts and Culture and the Omusati and Khomas Regional Directors of Education in Namibia. The study was approved by the University of Eastern Finland. All participants provided written informed consent to participate in the study.

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Authorship Contribution Statement

Jatileni: Concept and design, data acquisition, data analysis and interpretation, manuscript drafting, manuscript critical revision. Havu-Nuutinen: Editing/reviewing, statistical analyses critical revision, supervision. Pöntinen: Editing/reviewing, supervision

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