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Prospective Teachers' Perceptions, Reliance, and Barriers to ICT Integration in Mathematics Learning

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Abstract

Prospective teachers' (PTs') ICT integration (ICTi) for learning math (LM) has been studied in the global context, however, it lacks in the local context. This study served to bridge the gap by exploring PTs': perceptions toward ICT competence and integration; reasons for relying on technology; and the challenges encountered while LM. The methodology was grounded in interpretivism, induction, mono-method-qualitative, case study, and cross-sectional components. The participants' selection was based on convenient and purposive techniques. Data were collected through semi-structured interviews (SSI) and focus group discussions (FGD) and were analyzed using thematic data analysis. The findings informed positive perceptions of PTs toward ICTi where the purpose of relying on technology varied across participants. Though ICTi was found important, still there are inherent challenges associated with its integration, for example, scanning online material, encoding math language, and limited awareness of mathematics application software. The recommendations necessitate the development of special programs to offer hands-on learning experiences along with mitigating challenges for the prospective teachers to integrate ICT for LM. Future researchers may focus on variables through the blended model of teaching and learning that impact the academic performance of students in a math course.

Keywords: ICT skills, mathematics education, perceptions, ICT challenges, integration.

Introduction

In the 21st century, a technology-integrated curriculum uplifts students' knowledge and skills (Hue & Ab'Jalil, 2013) and offers a variety of resources including fun activities for teaching and learning (Surani & Hamidah, 2020). ICT offers several activities to increase students' motivation and expertise for learning math (LM) (Ndlovu et al., 2020). Moreover, websites offer video-watching-facility, particularly on 'YouTube' for clarification (Namome & Moodley, 2021), and increase student motivation and academic performance, further conceptual understanding, and present strategies for understanding LM concepts with ease (Chipangura & Aldridge, 2017). Moreover, ICT integration (ICTi) enriches the lecturing experience, improves content enrichment, and provides real-life situations which transform teaching (Wei, 2021). Similarly, if teachers guide students, game-based technology can foster a durable learning experience (Goodwin, 2020). Additionally, ICT use improves the educational experiences of teachers and students (Ottenbreit-Leftwich et al., 2010). Therefore, technology alters instructional methods, enhances student engagement, and promotes math knowledge (Paudel, 2015). However, the provision of infrastructure does not ensure ICTi (Apostolou, 2020) because the academic environment largely depends on teachers' efforts to harness the benefits of ICT.

Research indicates that teachers' characteristics—knowledge, beliefs, attitudes, and skills hold prime significance, which can predict technology integration in class (Watt, 1980). Similarly, teachers' behaviors in the classroom are shaped by their beliefs which influence judgments (Pajares, 1992, p. 307). Further, teachers' specific ICT attitudes and ICT usefulness affect their competency levels (Tondeur et al., 2018). Moreover, teachers' perceptions ascertain specific attitudes toward technology integration. Above all, ICTi requires skills and knowledge of computer applications, and the availability of ICT gadgets (Mohammed, 2021). Unfortunately, teacher-related problems, time constraints for learning technology, and lack of ICT competencies lower teachers' performance to yield desired outcomes (Shaikh & Khoja, 2013). Though ICT skillset is important, there also exist contingent factors for effective ICTi (Esteve et al., 2018). The scenario indicates insufficient evidence of technology integration in higher education institutions concerning learning math (LM).

Math teachers feel comfortable when integrating ICT as an association exists between new technologies and math teaching (John & la'Velle, 2004). Despite the application of authentic and context-specific methods of teaching math, the pedagogical strategies used by teachers for conducting classes, alienates many students from learning (Cassibba et al., 2021). Pedagogy assists in students' conceptualization, modeling, and learning of technological skills (Mohammed, 2021). However, teachers reluctantly accept technology at a slow rate and are not keen to use novel strategies (Orlando, 2014). Thus students' poor achievement in math is attributed to—anxiety, classroom milieu, teacher attribution, and teaching practices (Mohammed et al., 2012).

The operational skills of users, tools, and infrastructure available for ICTi create the working environment for the ICT users without which the reaps of technology fall short. Therefore, a combination of personal characteristics, pedagogical and technological skills, and infrastructural provision can influence PTs' integration of technology in LM. However, in the process of utilizing ICT resources, the prospective teacher might face challenges that hinder the process of ICTi. Moreover, ICTi has a specific purpose to rely on. Therefore, PTs' perceptions, ICT skills (proficiency), gadgets, and relevant infrastructure determine the ICTi for LM; and challenges and reliance on ICT are also pertinent variables to provide breadth to this study.

Research Questions

This study attempted to answer the following research questions:

1. What perceptions do prospective teachers hold towards ICT integration in learning math?
2. Why do prospective teachers rely on ICT for learning math?
3. When learning math, what challenges related to ICT do prospective teachers face?

Literature Review

Theoretical Framework

Rogers' (2003) diffusion of innovation theory explains that technology adaptation progresses over time following five stages in the innovation-decision process. The math teacher and students must: learn about innovation (knowledge); develop an interest in the value of innovation; adopt innovation in teaching and LM (decision); implement innovation, especially teachers (implementation); and resolve to integrate ICT in teaching and LM.

The technology acceptance model shows the user's intention, and perceived ease of use as determinants of individuals' adaptation and use of information technology (Venkatesh & Bala, 2008). The other variables around technology acceptance include voluntariness, experience, and subjective norms influence behavioral intention; result in demonstrability, job relevance, image, output quality, and subjective norm influence perceived usefulness. The anchoring factors include perceptions of external control, computer playfulness, computer self-efficacy, computer anxiety, along with adjustment factors: objective usability, and perceived enjoyment influence perceived ease of use. Moreover, an interrelated network of relationships exists among variables exhibiting the technology acceptance complexity.

Knezek and Christensen's (2016) determinants of technology integration comprise the attitude of the teacher (will), technology competency (skill), access to technological tools (technology), teaching with technology, and emerging technologies (pedagogy).

ICT in Education

ICT involves various sources to send, receive, manipulate, and exchange digital data (Aggarwal & Bal, 2020). ICT enables users to obtain the required information and provides possibilities for education to shape the future through ICTi (Ishaq et al., 2020; Wei, 2021). The effectiveness and adequacy of ICT depend on the availability of infrastructure and the competence-level of users (Tran et al., 2020). Further, ICT brings myriad activities which improve students' achievement and competence (Napitupulu et al., 2018). ICT elements—assistance, dissemination, and easiness enhance students' learning outcomes (Melo et al., 2020). The provision of ICT tools facilitates teachers and learners and the adaptation of interactive methods directly upgrades students' performance, which changes teachers' attitudes toward teaching and learning (Al-Ansi et al., 2021; Arkorful et al., 2021). Hence, ICT offers more interactive involvement than traditional teaching-learning processes. However, reference to LM through ICTi suggests inquiry in the context of this study.

Teachers' ICT-related Perceptions

Perceptions serve as enablers to influence teachers' behavior in the classroom (Mansour, 2008). For Eteokleous (2008) perception is about the way people view, understand, or interpret something. Fives and Buehl (2012) enlist perceptions as conceptions, attitudes, ideologies, values, opinions, perspectives, judgments, thinking, and dispositions. Moreover, teachers' perceptions can predict their integration of technology (Ottenbreit-Leftwich, 2010). Teachers' perceptions comprise stimuli that ignite action (Baucus et al., 2014) for ICT-related activities. Moreover, a bi-directional relationship exists between ICT and teachers' beliefs about teaching (Tondeur et al., 2018). Early in their career, novice teachers hold teacher-centered views toward ICTi, however, later novice teachers show more adaptability than veteran teachers (Englund et al., 2017). Literature is replete with teachers' perceptions on ICTi, whereas there is limited research on students' perspectives. Knezek and Christensen's (2008) model informs the importance of students' willingness for ICTi in LM. According to the model, ICT provides a conducive environment for students to learn math with ease and fun. Further, students' interest enables ICT application for LM. However, this phenomenon needs further exploration, particularly in LM.

ICT Integration in Teaching and Learning Math

ICT has introduced multiple ways to teach and learn new topics. The omnipresence of technology-based instructional designs has developed positive attitudes in teachers toward ICTi (Al-zboon et al., 2021). Moreover, the facilitation and access facets of technology boost teaching and learning practices (Al-Ansi et al., 2021). Consequently, ICT has transformed the way mathematics is studied (Das, 2021). A math teacher's ICTi aids students' problem-solving and critical-thinking skills and from an early age, students begin to learn to count, compare and recognize shapes and develop concepts of geometrical shapes and numerical skills through ICT (Das, 2019; Eleftheriadi et al., 2021). Aggarwal and Bal (2020) consider ICTi mandatory for students and teachers, and recommend many ICT applications like smart classrooms, social media platforms and other software such as 'MATLAB', 'Wolfram Mathematica', 'Maple', 'Graphmatica', 'GeoGebra', 'Math Mechanixs', 'Math Editors' and 'Geometry Pad.' A teacher with ICT competency can utilize the positive effects of technology-based teaching for students' learning, and better results (Tomaro, 2018). ICT competency refers to the capabilities, skills, and knowledge regarding the effective practice of digital tools in teaching and learning (Melo et al., 2020). Similarly, digital competency is searching for information and managing content, editing documents and tables, deriving formulas of mathematics, drawing expression and geometry graphs digitally, and solving related problems (Hossein-Mohand et al., 2021). The computer-based instructions positively impact students' motivation (Turk & Akyuz, 2016) and increase performance and learning outcomes (Van et al., 2015). While ICT offers much in math education, the room for further investigation justifies the need for this study.

Availability of ICT Infrastructure

Knezek and Cristensen (2008) informed that ICT tools help students in LM. In Sheila's (2016) model, the ICT infrastructure availability—hardware, software, and digital systems, are important for high graders to learn math. Internet is the second factor that supports remote and virtual classrooms through presenting and sharing learning material appropriate for the application (Woolliscroft, 2020). The math application, 'Math Solver,' offers an easy and simple way to learn through a problem-solving approach (Divjak et al., 2011). 'Math Tricks' is used for presenting formulae to calculate math problems fast (Gardner, 2014). 'Photomath' allows one to take pictures of math problems, and see the answers on the screen (Abdillah et al., 2021). 'MalMath' provides steps to solve problems from logarithms to algebra, integrals, and trigonometry (Goncharenko et al., 2020). 'Mathway' answers from the easiest to the most difficult math questions in detail (Hadjinor et al., 2021). 'Mathematics' answers problems about sin, cos, tan, and linear to vector (Aslan et al., 2017). However, despite having many applications, the functional effectiveness and appropriateness still need assessment.

ICT Integration in Pakistan

Khokhar and Javaid (2016) studied the views of students (grades seven through eleven) and teachers concerning ICT use in the academic and non-academic environment through a questionnaire where both were found using ICT for education, communication, and entertainment purposes. While teachers claimed the effective use of ICT, students held views different from the claims that teachers made.

Ahmad and Sheikh (2021) surveyed 275 university students and found positive correlations among ICT-ability, accessibility, and availability of ICT resources along with the benefits of ICT for searching and consulting a variety of information, and accomplishing tasks quickly which increases productivity.

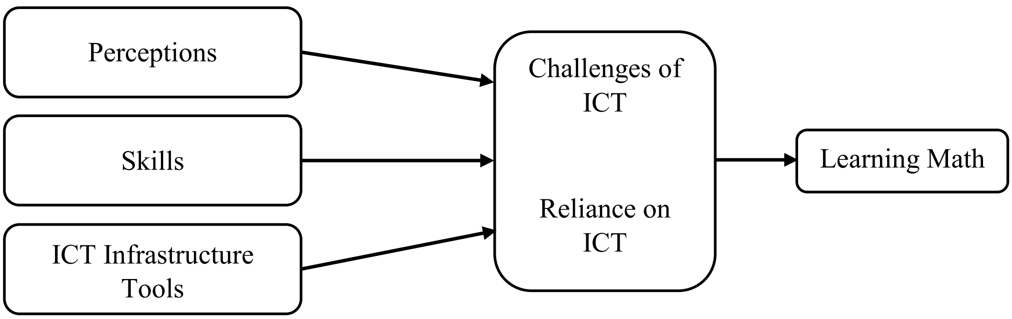
Bughio et al. (2014) explored the trends in e-learning and the pertinent technologies used in distance learning programs. Findings revealed technology mismanagement, high failure or dropout rate, limited capacity building of teachers, weak relationships among students and teachers, and financial constraints emerged as issues. Guidance, cooperation, orientation of students, trained staff provision, information sharing based on coordination among all stakeholders, and professional development of teachers and fund allocation appeared as remedies suggested for distance learning programs in seven universities of Pakistan.

Conceptual Framework

Dogan et al. (2021), Sheila (2016), Knezek and Christensen (2008) set the base for this study (Figure 1). Here, perceptions are the internal factor that determines the optimization of ICT resources.

Figure 1

The Conceptual Framework



Methodology

"The methodology was grounded in interpretivism, the approach was inductive, the methodological choice was mono-method-qualitative, the strategy was multiple case studies, and the time horizon was cross-sectional" (Saunders et al., 2019, p.130). The data collection was completed through semi-structured interviews (SSI), and focus group discussions (FGD), which led to a thematic analysis of the data.

Selection of the Participants

The phenomenon of LM was explored by applying multiple case studies, and convergence of data from FGD (George, 2022). Twenty of thirty participants were selected from the total population and were briefed about the study's purpose; however, sixteen participants consented to participate. Among all, twelve participants were categorized for interviews and focus group discussions while the remaining four were thanked and informed that, if required, they would be contacted in the future. The selection criteria included: seventh-semester PTs with age ranges from 22 to 23 who had completed three math content courses, and two math pedagogy courses during B. Ed. program where the characteristics of the participants matched with the study need. Out of twelve, four interviewees were male; four males in FGP1, three males, and one female in FGP2.

Data Collection and Analysis

The research questions suggested qualitative semi structured interview approach for knowing the feelings, unobservable behavior, or people's perceptions and interpretations of the world around participants (George, 2022). Furthermore, the SSI allows flexibility between the highly structured and unstructured questions (Merriam & Tisdell, 2016, p. 110) which includes an interview guide of broad areas of research questions (sometimes sub-questions). FGD research method was used to gather data from a group of participants (George, 2022).

An invitation to participants was sent, and formal consent was sought. Later, a mutually convenient time and place were set for the SSI and FGD. The participants were informed of the ethical considerations of the study. Next, approval for SSI and FGD, and consent for audio recording were sought.

The thematic analysis technique of Delve and Limpaecher (2020a) was adopted—familiarizing with the data, creating initial codes, grouping similar codes, grouping codes into themes, and reviewing and revising themes, until the saturation point (George, 2022). The validity was determined through participant feedback and low-inference descriptors.

Findings

The study purpose was achieved through data garnered from the voluntary participation of PTs. The findings represent five themes that emerged after the convergence of SSI and FGD data with the support of quotes followed by an interpretation of themes. The responses with the small letter and the number ‘*i2*’ indicate interviewee two; whereas ‘*P1*’ represents FGD participant one.

Positive Perceptions toward ICT Integration for Learning Math

The response in the FGD elucidated that the PTs indicated positive perceptions toward ICTi for LM as P3 expressed, “ICT applications have made a 360-degree change in my learning of math, as I have learned 80% of it through ICT apps.”

P2 shared:

> I have used ICT in learning math, and I believe that ICT is a very helpful source for learning math. For example, a teacher takes 10 math problems inside the class and students solve some in the class rest will be solved at home. When they start solving them at home, if they face any difficulty, they just leave to learn it on their own. Here, students get help from ICT first and then can solve it easily. In this way, students increase their level of interest in learning math. I have used ‘Photo-math’ to learn math.

P4 maintained:

> Whenever I face any sort of difficulty in solving a math question I go to a friend and if he can’t do it then I use ‘Google’ to solve and learn it properly. Even if there are some problems or questions that can’t be solved by using google, then I use ‘YouTube’ to solve it. In case, if I can’t understand or solve any question through the use of ICT then I go to teachers and they help me solve it.

The response interpretation alluded that participants reflect positive perceptions toward ICTi as it helps them in understanding and building discussions around those concepts of math that are hard to understand through lectures. Similarly, free-to-use application software addresses the needs of students by consulting difficult concepts on applications making math learning a meaningful and effective experience. Moreover, the applications based on clarifying math concepts also offer a repertoire of choices for selection from a variety of application systems as per the appropriateness level of the learner. It is important to note that participants use self-effort to solve a math problem, then seek help from online resources, and finally approach the teacher, if required. The utilitarian perspective enables the learning practices of PTs to reflect on the instrumentality of ICTi.

Teachers’ ICT Competence toward Learning Math

Teachers’ ICT competence toward LM revealed that most participants had moderate ICT competence. The participants’ self-perceived views denoted moderate competence in ‘MS Word’ and ‘MS PowerPoint’, and basic competence in ‘MS Excel’.

For example, “I am not that much efficient in using ‘MS Word’, but I can relate to myself that I can use it at an average level” (i2). Similarly, “I consider that I am skilled at the average level of ‘MS Word’” (P1).

The analysis of responses indicated PTs’ moderate competence in ‘MS Word’.

Similarly, moderate competence was also reported in ‘MS PowerPoint’. For instance, “I am at the middle level in ‘MS Office’ same is the case with ‘PowerPoint presentation’” (i3). “I am not that much, but quite proficient which means at an average level in ‘MS PowerPoint’” (i1).

The response analysis reflected PTs’ moderate competency in ‘MS PowerPoint’. The moderate use of ‘MS PowerPoint’ suggested either a decrease in the motivation of PTs or may be attributed to a lack of prior ICT experience. The computations yield a touch lower than seven. Hence, PTs need to enhance their competency in the application software to improve the math learning experience. Similarly, PTs used ‘MS Excel’ at a very basic level. For example, the answers of the participants suggest “I am at a basic level in my ‘MS Excel’” (P3). “No, I am not that proficient means below the average level in ‘MS Excel’” (i1).

The answers reflected participants’ basic-level competency in ‘MS Excel’, which can help students apply different math functions, and offers hands-on experience of interaction with ICT to boost confidence. However, insufficient skills to integrate technology may lead to disappointment as with low-confidence PTs' motivation diminishes, which serves as pivotal for LM.

Moreover, the participants' responses suggest their level of ICT competence is at an average level. For instance, "I am at the intermediate level in other application software because I can do things at an average level by using this software" (P1). "I can say that I have good competency in using different ICT applications, so, I keep myself in the category of average level" (P3).

The analysis of responses reported the average-level ICT competence of PTs to use a variety of online sources. So, most PTs integrate technology into learning is partially hampered by a lack of advanced ICT skills. Individuals with requisite level-specific ICT skills can perform more efficiently than others. A limited skillset to operate basic applications creates low confidence in math application use.

Application of Online Sources for Learning Math

The response to the application of online sources for LM informed that participants used a variety of ICT application software. For example, "I am using different ICT applications on daily bases, these are 'YouTube', 'Google', 'Khan Academy' and 'Noon Academy'" (P1). Moreover, interviewee 3 maintained:

> I believe that technology helps me a lot in learning math because it helps me cover most of the concepts the teacher does not deliver in class. I visit 'Google' and 'YouTube' and try to learn those concepts (i3).

The answers informed that ICT applications help learn math easily and quickly. The participants highlighted the usefulness of ICT; and the interest that online tools create for LM. The attractions of ICTi, and the range of ICT applications offer support from novice to expert levels for LM. Moreover, ICTi helps in developing and maintaining student interest in LM which is crucial for learning difficult math concepts. The transformation of ICT evolving into new forms comes with a more user-friendly solution to math-related problems.

The Practicality of ICT for Learning Math

The response analysis revealed participants' perceived practicality of ICT resources for learning math. For example, "*Mostly, I have used ICT during my third content [of math] where I got many difficult topics such as integration and derivation. Furthermore, it increases my level of interest in LM*" *(P3). "ICT applications have changed my way of LM. In the beginning, I used to face many difficulties in learning difficult math topics, but now, I can handle these with ICT support*" *(i4).*

The quotes indicate the reasons for ICTi toward understanding math concepts. The availability of technology allows for sparing participants' time to focus on the problems for LM. Moreover, participants rely on technology for its easiness in using ICT applications for LM. For example,

> When I face any kind of difficulty in math, ICT applications help me to understand difficult concepts. I use ICT because I feel comfortable LM with ICT. ICT increases my interest to solve math problems" (i4). "I believe that all the application software are easy to use and help learn anything, but I believe that 'YouTube' is just a miracle for me, especially for LM (i2).

The participants indicated ICTi for a variety of reasons: learning difficult math concepts, easy-to-use applications, ease of interface with technology, and videos on math processes to decode math concepts. Moreover, ICT assists in the effective involvement of users which in turn develops an interest in solving math problems. Thus, the practicality of ICT resources for LM makes it easy for participants to integrate into a setting that enhances learning.

Challenges of Scanning Online Sources for Learning Math

Most participants faced challenges associated with math learning situations. The participants stated, "I face some hindrances in searching authentic and relevant information and difficulties in understanding math language" (P2). "I can't use ICT applications properly for LM" (P4).

Similarly, a participant (i1) expressed:

> So, the math language barrier comes in front. Another problem is that students are not aware of teachers who are not familiar with those applications. I believe that this is the biggest challenge that my teachers did not educate me to take help from these [ICT] tools.

The response analysis revealed challenges that affect participants' competence to learn math which include difficulty in understanding math language, searching for authentic information, limited ICT competencies, teachers' limited ICT awareness, and lack of orientation for participants to use math applications.

Discussion

As a result of the qualitative data analysis based on the case study, the ICTi towards LM informed positive perceptions of PTs for ICTi, limited competence for effective integration of ICT, different reasons to rely on technology, and potential challenges in the way of ICTi for LM.

The findings revealed the usefulness and easiness which develop PTs' positive perceptions toward ICTi for LM. This corroborates Turk and Akyuz's (2016) suggestions that positive perceptions influence students' motivation through computer-based instructions for LM. Moreover, Van et al. (2015) reaffirmed computers as enablers that improve students' performance and learning outcomes in math expressions. Additionally, PTs' exhibited a moderate level of proficiency in operating educational devices and applications. The finding suggests more hands-on experiences by creating more opportunities for filling the skill gap of PTs (Aslan & Zhu, 2015). Kafyulilo et al. (2015) reiterated that university students need to learn digital competency to integrate ICT applications effectively for LM. Furthermore, Melo et al. (2020) suggested that a teacher must possess strong digital competence, skills, and knowledge to execute effective and efficient integration of ICT.

The PTs' reliance on ICTi rests on decoding difficult concepts of math, easiness in technology use, improvising grades, self-motivation, and quick solutions to math problems. Similarly, a math teacher's ICTi helps students' problem-solving and critical-thinking skills (Das, 2021). Moreover, ICT fosters students' motivation, and performance, and retains students' interest in LM (Lee, 2021).

Finally, the obstructions of searching relevant information on the internet, difficult math language, and limited knowledge of ICT use cause hindrances to ICTi. Msomi and Bansilal (2018) confirmed that university students encounter—a lack of knowledge and skills for ICTi, inadequate ICT resources, underutilization of ICT for LM, and teachers' low-level expertise in integrating ICT in teaching math.

Conclusion and Implications

As ICT has become instrumental in math learning, as such, it is pertinent to understand PTs' perceptions regarding ICT competence, integration, reliance on technology; and challenges of ICTi. With limited competence, less expertise, and less infrastructural support, PTs remain uncertain to harness efficient ICTi outcomes for LM. Moreover, self-effort and a supportive institutional system are required to mitigate ICT-related challenges and ensure student engagement. Based on the findings, it can be concluded that technology-teacher-student-infrastructure and coordination are necessary for technology integration for LM. The study poses limitations for the reuse of findings elsewhere. The small sample size limits the generalizability of findings of this study. Furthermore, the participants were sampled from the education department only, thus, it limits implications for other departments. Finally, the methodological choice suited the qualitative design, however, the quantitative study factors related to PTs' demographics and other variables might have produced different results.

It is suggested to provide effective support to students and train teachers to become role models and create a conducive teaching-learning-environment for enhancing the ICT competence of PTs which leads to academic achievement in LM. Also, in-service professional development and self-initiatives equip teachers to develop the necessary ICT skills for the optimal use of technology. The provision of adequate infrastructure complements the teaching-learning needs of LM. Also, teachers' positive perceptions influence the integration of application software for fostering math learning. Moreover, awareness sessions on searching online material, and decoding math problems can benefit PTs' approach to authentic content which saves time and energy for LM. Similar studies can be conducted in other contexts by applying quantitative design, and employing multiple datasets to investigate ICTi in teaching and LM.

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