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On Digital Divide within a Developing Country: Investigating Gender and Location Influence in ICT Study Engagement in Cambodia

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Abstract. In Cambodia, as in many parts of the world, access to Information and Communication Technologies (ICT) education is crucial for individual empowerment and national development. However, disparities in access and participation persist, particularly regarding gender and geographical location. Structured into two studies, our research effort investigates these inequalities by analyzing data from the Cambodia Academy of Digital Technology (CADT) entrance exams conducted between 2020 and 2022. Study 1 focuses on gender differences in ICT study engagement, revealing significant disparities in application and success rates among men and women. Study 2 explores location differences in ICT study performance, highlighting the impact of unequal technological development across urban and rural areas. Our findings underscore the urgent need to address these disparities through targeted interventions. Such initiatives could be supported by developing Culturally-Aware Technologies targeting characteristics and challenges within Cambodian society.

Keywords: Digital divide · ICT Education · Gender Disparity · Location Influence · Cambodia · Educational Equity · Higher Education.

1 Introduction

The digital divide, a pressing global issue of unequal access to information and communication technologies (ICT), has been extensively studied [5, 28, 23]. This divide manifests in various forms, such as disparities in internet access [30, 29], digital literacy [9, 27], and the availability of technological resources [7, 6]. For instance, in many developing countries, a significant portion of the population needs reliable internet access, hindering their ability to participate in the digital economy [10, 1]. In contrast, more developed nations enjoy widespread connectivity, facilitating innovation, education, and economic growth. This imbalance

has far-reaching consequences, impacting education, economic opportunities, and social inclusion. The urgency to address this issue is paramount.

One prominent consequence of the digital divide is its effect on education. In regions with limited ICT access, students often miss out on digital learning tools and resources, leading to lower educational outcomes [12, 8]. For example, during the COVID-19 pandemic, the shift to online learning exacerbated educational inequalities, as students without internet access or digital devices could not fully participate in remote education [15, 14]. This issue affects immediate learning and has long-term implications for employment prospects and socioeconomic mobility.

In the field of Artificial Intelligence in Education, the Digital Divide and its consequences have already been discussed on a global scale [24, 4]. In the context of this study, we provide additional insights by investigating possible digital divide within a developing country, Cambodia. We focus on 2 dimensions: gender and localization. Our research question investigates the factors influencing engagement and commitment in ICT studies in Cambodia. By dissecting the interplay between gender and geographical location, we seek to uncover the underlying dynamics shaping access to and participation in ICT education.

Our paper is structured into two distinct yet interconnected studies to address our research question. We begin by examining gender differences in ICT study engagement and investigate location-based disparities in ICT study performance. Each study is preceded by a discussion of our general methodology, with specific details provided for each analysis. We present our findings from both studies, accompanied by preliminary discussions to contextualize the results within the broader landscape of STEM and ICT education disparities.

Our study not only contributes to the existing literature by offering insights into the digital divide within Cambodia but also provides practical implications for the design and implementation of targeted interventions. By comparing our findings to global trends in STEM and ICT education disparities, we underscore the urgency of addressing these issues on a national and international scale. Ultimately, our research aims to advance discussions on educational equity and pave the way for initiatives aimed at bridging the digital divide in Cambodia and beyond.

2 State-of-the-Art

The digital divide, a significant global issue characterized by unequal access to ICT, has far-reaching consequences [1, 12, 2]. Studies have shown this divide is prevalent across various countries, leading to disparities in education, employment, and overall quality of life. For instance, limited access to the internet and digital devices hampers educational opportunities in many developing nations, affecting students' ability to engage with modern learning resources and tools [21].

The digital divide particularly impacts women, who are underrepresented in STEM fields, including ICT [11, 19, 17]. Research indicates that women face

multiple barriers, such as societal norms and gender biases, which discourage their participation in these fields. This underrepresentation is a global issue [16] observed in developed [26] and developing [3, 22] countries. It contributes to the broader gender gap in the technology and engineering sectors [18].

Within this discourse, a research [26] has extensively discussed the unequal distribution of the digital divide among countries and its potential impact on future populations. Their insights highlight the stark differences between wealthy Western countries and the rest of the world, underscoring how access to ICT can influence economic and social development. This disparity not only affects individual opportunities but also has broader implications for national progress and competitiveness in the global market.

Similarly, [4], drawing on research from psychology, has explored similar imbalances within the field of artificial intelligence in education. Their work suggests that psychological factors, including self-efficacy and societal expectations, significantly shape individuals' engagement with ICT.

Efforts to address the digital divide have been varied and multifaceted [20]. Governments, non-governmental organizations, and private sectors have launched initiatives to improve ICT access and education [25]. These efforts include providing affordable internet services, distributing digital devices to underserved communities, and implementing educational programs that promote digital literacy. Additionally, there is a growing emphasis on creating inclusive technologies that cater to diverse user needs, thus fostering a more equitable digital environment [13].

In this context, our research makes a unique contribution by investigating the digital divide within a developing country, with a specific focus on Cambodia. By examining gender and location dimensions, we aim to uncover the factors influencing engagement and commitment in ICT studies. Our study not only offers new insights into the digital divide within Cambodia but also provides practical implications for the design and implementation of targeted interventions. Our research primarily aims to advance discussions on educational equity and pave the way for initiatives to bridge the digital divide in Cambodia and beyond.

3 Method

Our study analyzed data from entrance exams administered by the Cambodia Academy of Digital Technology (CADT) over three years (2020-2022), and personal data used in our analysis were anonymized to ensure confidentiality and compliance with data protection regulations. CADT is a premier institution in Cambodia dedicated to advancing digital technology education and training, playing a crucial role in developing the nation's ICT workforce. Unlike other universities in Cambodia, CADT requires students to pass an entrance exam before they can enroll in a bachelor's program. Before taking the entrance exam, students must choose one of three majors they intend to enroll in, making the entrance exam data particularly valuable for our research.

The initial dataset comprised 7,527 records, including detailed information on applicants' gender, chosen majors, and exam results. Due to incomplete location data, our investigation of geographical factors was based on a subset of 3,650 records.

The entrance exams covered three majors, each representing a critical area within the ICT field:

1. **Computing and Technology:** this major focuses on foundational and advanced computing concepts, including software development, algorithms, data structures, and systems design. Graduates typically pursue careers as software developers, systems analysts, data scientists, and IT consultants.
2. **Telecommunications and Networking:** this field deals with designing, implementing, and managing communication systems and networks. It includes wireless communication, network security, and the Internet of Things (IoT). Career opportunities for graduates include network engineers, telecommunications specialists, and cybersecurity experts.
3. **Digital Business and Management:** this major combines business management principles with digital technologies. It covers areas like e-commerce, digital marketing, and data-driven decision-making. Graduates often work as digital marketing managers, e-commerce strategists, business analysts, and IT project managers.

In addition to analyzing entrance exam data, we conducted a survey using Google Forms with 25 women currently engaged in ICT studies or employment. Based on our analysis results, this survey aimed to gather qualitative insights into their experiences, challenges, and perspectives regarding gender imbalances in the ICT field.

In the following sections, we will examine potential gender-based imbalances in ICT study engagement and investigate whether geographical location contributes to differences in ICT study performance. This approach allows us to understand the factors influencing ICT education participation in Cambodia comprehensively.

4 Study1: Gender Differences in ICT Study Engagement

4.1 Research Hypothesis

Hypothesis 1 posits that there is a gender difference in performance when applying for ICT studies in Cambodia. This hypothesis is based on the global trend that women are underrepresented in STEM fields, including ICT. Various socio-cultural factors, such as traditional gender roles and biases, often discourage women from pursuing careers in these areas. By investigating gender disparities in ICT education, we aim to understand whether similar patterns exist in Cambodia and how they affect women's participation and success in this field.

4.2 Results

Table 1 presents an overview of the gender distribution and success rates among applicants to ICT majors at CADT. This table offers insights into the disparities in ICT study engagement between male and female candidates. It outlines the proportion of applicants by gender across different majors, including Computing and Technology, Digital Management and Business, and Telecommunications and Networking. Additionally, it showcases the success rates of male and female applicants in these majors, providing a comparative analysis of their performance during the entrance exam process. This information sets the stage for a deeper examination of gender differences in ICT study engagement in Cambodia.

Table 1. Application and Success Rates by Major and Gender

Major	Applications (rate)		Success (rate)	
	Men	Women	Men	Women
Computing and Technology	3639 (70.55%)	1519 (29.45%)	2694 (74.03%)	1027 (67.61%)
Telecommunications and Networking	607 (61.69%)	377 (38.31%)	405 (66.72%)	215 (57.03%)
Digital Management and Business	591 (42.67%)	794 (57.33%)	426 (72.08%)	442 (55.67%)

The table 1 shown that men engage more in ICT studies than women in two of the three majors offered at CADT. Specifically, men constitute the majority of applicants in Computing and Technology and Telecommunications and Networking, making up 70.6% and 61.7% of applicants, respectively. In contrast, Digital Management and Business attracts more female applicants, with women comprising 57.3% of the total. However, data from CADT illustrates the underperform of women compared to men in all of the 3 examinations. In Computing and Technology, the data shows that men have significantly higher success rate of 74% compared to 67.6% for women succeeding in this exam. In Telecommunications and Networking, the pattern persists with men achieving a success rate of 66.7%, versus 57% acceptance for women). Finally, the stronger performance gap is observed in Digital Management and Business with 72% of men vs 55.7% of women succeeding in its entrance exam, despite being the sole major where there are actually more women applicants than men.

In order to investigate these results, a total of 25 Cambodian women were contacted, and 16 answered positively (average age 21, SD 4). Responders are from various regions of Cambodia with varying levels of technological development, such as Kandal, Kratie, Kompong Speu, Phnom Penh, Siem Reap, and Banteay Meanchey. All are or have been engaged in ICT studies (9 are current students whereas 7 already have a degree and are working in an ICT-related job). Indeed, targeting women with an ICT-related background was a way to better extract specific characteristics and challenges they may have personally faced or witnessed when engaging in ICT studies.

Many respondents agreed that one of the main explanations for the observed gender imbalances might be cultural and societal norms. For instance, one responder wrote, “Women are less interested in technology majors compared to

men generally. Norm leads us to believe that technology fields are men-dominated and more suitable for men”. Another similarly said, “The way Cambodian parents raise their children, for example, they believe women should be studying accounting, banking majors”.

Another possible explanation provided by many respondents was the lack of early exposure to technology for women compared to men. A Computer Science student from the high development region explained, “Boys tend to receive more encouragement to engage with technology from a young age, giving them an advantage in tech-related skills”. Another respondent from a medium-high development region added, “Men are more likely to play games and get familiar with computers earlier than women”.

A third popular explanation was the perception that ICT majors, except for Digital Management and Business, are too difficult or complex for women. One respondent mentioned, “From my point of view, those two majors preferable for men might involve complex math and calculations, as well as discovering new tech. While studying business is a trend nowadays, women might feel they could manage that without involving any complexities in the field”. And one respondent from the low development region said “In fact, most ICT skills for men because this skill is very difficult, sometimes women are weak and cannot master this skill”.

Finally, some respondents highlighted the impact of role models and mentorship. One respondent suggested that the lack of female role models and mentors in ICT fields discourages women from pursuing these majors: “Without visible examples of successful women, young women might be less likely to pursue these majors”.

In summary, the survey results highlight the significant gender disparities in ICT study engagement in Cambodia. Cultural norms, societal expectations, and a lack of role models and mentorship contribute to the lower participation and success rates of women in ICT fields.

5 Study 2: Location Differences in ICT Study Performance

5.1 Research Hypothesis

Hypothesis 2 posits that there exists a location difference in performance when applying for ICT studies in Cambodia. This hypothesis is grounded in the stark disparities in technological development across different country regions. Urban areas benefit from modern infrastructures, including reliable electricity, widespread internet access, and advanced computing facilities. In contrast, many rural areas need more essential technological facilitation, limiting access to ICT resources. Consequently, individuals from urban areas may have greater exposure to technology and more ICT education opportunities than their counterparts in rural regions. This hypothesis seeks to explore the impact of these geographical disparities on ICT study performance and engagement, aiming to shed light on the unequal distribution of educational opportunities within Cambodia.

5.2 Results

Table 2 shows the geographical dynamics of ICT study performance in Cambodia. Our analysis revealed intriguing patterns, pointing out the disparities and challenges faced by students across different regions.

Table 2. Application and Success Rates by Geography Location

Geography Location	Applications (rate)		Success (rate)	
	Number	Percentage	Number	Percentage
High development	1180	32.33%	854	72.37%
Medium-high development	1507	41.29%	1027	68.15%
Medium-low development	850	23.29%	565	66.47%
Low development	113	3.10%	70	61.95%

CADT data included responders from different provinces across Cambodia, including Kandal, Kratie, Kompong Speu, Phnom Penh, Siem Reap, and Banteay Meanchey.

High-development regions emerged as the frontrunners, boasting a substantial influx of applications for ICT majors, and the highest success rates. Following closely behind, medium-high development and medium-low development regions also showed a notable interest in ICT studies and a commendable level of academic performance among students. However, the picture changes as we move to low development regions. Here, we observed fewer applications for ICT majors and comparatively lower success rates.

In other words, candidates from the more technology-savvy regions are the more likely to apply to, and succeed in entering an ICT-related major, which would likely amplify the existing digital divide between Cambodian regions.

These findings underscore the urgent need for targeted interventions and policies to address the unique needs and barriers faced by students in less developed regions. By investing in infrastructure, educational programs, and support systems tailored to the specific challenges of these areas, we can work towards leveling the playing field and ensuring equitable access to ICT education for all students, regardless of their geographical location.

Moreover, these insights have broader implications for Cambodia’s digital development agenda. By addressing the geographical disparities in ICT education, we cannot only provide equal opportunities for all students but also lay the foundation for a more inclusive and digitally empowered society. This, in turn, will lead to a more robust and innovative ICT sector, contributing to the nation’s progress in the digital age.

6 Opportunities for Culturally-Aware Technologies

The findings from our study underscore significant gender and location disparities in ICT study engagement and success rates in Cambodia. Culturally-aware

technologies could help addressing these disparities by providing culturally-specific incentives towards engaging in ICT education. Here, we discuss potential strategies and technological interventions to bridge these gaps.

6.1 Gender-Sensitive Educational Technologies

To tackle the gender imbalance in ICT fields, educational technologies can be designed to focus on inclusivity and gender sensitivity. Examples include:

1. **Role Model Integration:** incorporating stories and case studies of successful women in ICT into educational content can inspire and motivate female students. Virtual mentorship programs and interactive sessions with female ICT professionals can provide guidance and encouragement.
2. **Customized Learning Paths:** adaptive learning platforms that tailor content to individual interests and strengths can help female students find a personalized and engaging entry point into ICT subjects. Highlighting interdisciplinary applications of ICT, such as digital business and management, can make the field more appealing.
3. **Supportive Online Communities:** creating online forums and social networks where female students can connect, share experiences, and support each other can help build a sense of community and reduce feelings of isolation.

6.2 Geographically-Aware Learning Solutions

Addressing location-based disparities requires solutions that consider the varying levels of development and access to resources across different regions:

1. **Mobile Learning Platforms:** given the widespread use of mobile phones, developing mobile-friendly educational platforms can ensure that students from low-development areas can access high-quality ICT education. These platforms can offer offline capabilities to accommodate areas with limited internet connectivity.
2. **Localized Content:** developing educational materials that reflect the local context and language can make ICT education more accessible and relevant to students in different regions. It includes using local examples, case studies, and culturally appropriate teaching methods.
3. **Remote Tutoring and Mentorship:** leveraging videoconferencing and other remote communication technologies, students from underdeveloped regions can receive tutoring and mentorship from experienced educators and professionals. This can help bridge the gap in educational resources and support.

6.3 Inclusive Policy and Infrastructure Development

Beyond technological solutions, policy and infrastructure play a crucial role in addressing these disparities:

1. **Government and Institutional Support:** policies that promote gender equality in education and provide scholarships or financial support for female students and those from underdeveloped regions can encourage more diverse participation in ICT fields.
2. **Enhanced ICT Infrastructure:** investing in developing ICT infrastructure in underdeveloped regions can ensure that students have the necessary tools and resources to pursue ICT education. It includes improving internet connectivity and providing access to computers and other digital devices.
3. **Public Awareness Campaigns:** raising awareness about the importance of gender diversity and regional equity in ICT through public campaigns can help change societal perceptions and encourage more inclusive participation.

By leveraging culturally aware technologies and implementing supportive policies, it is possible to address the gender and location disparities in ICT education in Cambodia. These strategies promote inclusivity and ensure that ICT education's benefits are accessible to all population segments. As Cambodia continues to develop its digital economy, fostering a diverse and inclusive ICT workforce will be essential for sustainable growth and innovation.

7 Limitations

While this study provides valuable insights into the gender and location disparities in ICT education in Cambodia, several limitations must be acknowledged to ensure a comprehensive understanding of the findings and their implications.

1. **Positive Bias Among Female Respondents:** responders of our survey to investigate gender imbalance were all women involved in the ICT domain, either as students or employees. It helped highlighting issues and challenges they may have faced to do such studies but also introduces a potential positive bias, as these respondents are likely to have a more favorable view over ICT than the broader woman population of women. Future studies should similarly investigate barriers and challenges faced by women who chose not to pursue ICT studies.
2. **Incomplete Picture of Degree Completion:** the collected data focuses on entrance exams for ICT-related degrees. However, dropout rates during bachelor programs are not considered. If reasons behind the lack of engagement toward ICT studies also fuel higher dropout rates, this could exacerbate the observed gender and location imbalances, and further widens the digital divide in Cambodian society. Overall, it is crucial to gather and analyze data on how many students, particularly women and those from lower-income regions, complete their degrees, in order to understand the full extent of the digital divide and its implications for the future development of Cambodia's ICT sector.
3. **Need for Comprehensive Data:** comprehensive data on enrollment, retention, and graduation rates by gender and location are needed to fully address the digital divide and its impact on Cambodia's future evolution. By

highlight the importance of having thorough information about the number of students enrolling in ICT programs, the number staying in those programs, and the number of graduates broken down by gender and location. This detailed data helps us understand different groups' specific challenges in ICT education. With this knowledge, we could create targeted programs to support everyone's success. Unfortunately, we do not have all this detailed data, which makes it harder to fully understand the digital divide in Cambodia and how it might affect the country's future.

8 Conclusion

In this study, we explored the gender and location disparities in ICT education in Cambodia, highlighting significant imbalances that may have far-reaching implications for the country's digital future. Our findings align with global patterns of unequal access to ICT, particularly regarding the lower representation of women in STEM fields and the impact of socioeconomic factors on educational opportunities.

The CADT entrance exam data analysis revealed a marked gender imbalance, with men constituting the majority of applicants and successful candidates in Computing and Technology, and Telecommunications and Networking majors. Conversely, women were likelier to apply in the Digital Business and Management major, indicating a preference or perceived suitability for business-oriented ICT fields, but their performance remained lower than men's in this entrance exam as well.

Geographical disparities were also evident. Students from high development regions had higher application and success rates in ICT majors, those from medium-high and medium-low had decent performance in the entry exams, whereas students from low-development regions were by far the least numerous and successful. It highlights the significant impact of socioeconomic status and regional development on access to and success in ICT education.

Our study contributes to the broader discourse on digital equity by providing evidence of internal disparities within a developing country, mirroring global challenges. The observed imbalances highlight the necessity for targeted interventions to address the digital divide in Cambodia. Policies encouraging women's participation in all ICT fields and initiatives to support students from less developed regions are essential. Programs that provide early exposure to technology for girls and promote gender-neutral perceptions of ICT careers have immense potential. They could help balance gender representation and pave the way for a more inclusive future in ICT education. In such a context, Culturally-Aware Tutoring Systems could be key in implementing such programs by providing individualized guidance and support according to cultural norms and challenges.

Furthermore, our study contributes to the existing literature by offering insights into Cambodia's digital divide. It provides practical implications for the design and implementation of targeted interventions. By comparing our findings to global trends in STEM and ICT education disparities, we underscore the ur-

gency of addressing these issues nationally and internationally. Ultimately, our research aims to advance discussions on educational equity and pave the way for initiatives to bridge the digital divide in Cambodia and beyond.

To extend the scope of this research, future endeavors should delve into the development of culturally intelligent features within ICT education. It entails designing curricula, tools, and platforms sensitive to learners' cultural context, thereby fostering inclusivity and engagement. Additionally, exploring innovative pedagogical approaches that cater to diverse learning styles and backgrounds can further enhance the effectiveness of ICT education. Moreover, integrating culturally relevant examples and case studies into the curriculum can facilitate a more profound understanding and relevance for learners from different demographic groups. However, advancing towards a more inclusive digital economy necessitates collaborative efforts across government, educational institutions, and the private sector. By synergizing research and practice, we can develop tailored interventions that address the unique challenges faced by underrepresented groups in ICT education, bridging the digital divide and fostering equitable opportunities for all.

In conclusion, the urgency of addressing gender and location disparities in ICT education cannot be overstated. It is a crucial step towards fostering Cambodia's more equitable and prosperous future. By ensuring that all individuals, regardless of gender or socioeconomic background, have access to quality ICT education, we can empower a diverse workforce capable of driving innovation and growth in the digital age.

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