

AIT 580: Project Assignment 4
Students' Adaptability Level in Online Education
Final Project

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Introduction:

I found this dataset titled "Students Adaptability Level in Online Education" [1]. This dataset comprises demographic information like Gender, Age, and Education Level, along with technological details such as Internet Type, Network Type, and Device used. Additionally, it delves into various aspects of the learning experience, including Location, Load-shedding, Class Duration, Self LMS usage, and Adaptivity Level.

You can find this dataset hosted on Kaggle, a platform known for its collection of datasets catering to machine learning and data science projects. The data was originally gathered for a collaborative research paper titled "Students' Adaptability Level Prediction in Online Education using Machine Learning Approaches." This paper delves into the effectiveness and adaptability of students in the context of online education, with a specific focus on the unique circumstances prevailing in Bangladesh after the COVID-19 pandemic. The authors behind this study, namely Mahmudul Hasan Suzan, Nishat Ahmed Samrin, Al Amin Biswas, and Aktaruzzaman Pramanik, conducted both online and physical surveys across various educational levels, encompassing School, College, and University, to gather valuable data regarding students' socio-demographic factors and their experiences with online education.

The primary objective of this paper is to dissect and analyze pertinent factors related to online education. It seeks to provide insights to decision-makers within educational institutions regarding the effectiveness of online education and its potential to enhance the learning journey for students. Additionally, the research aims to bridge the gap between online and traditional classroom-based education in Bangladesh, exploring potential moderating effects of various factors such as gender, age, educational level, location, class timings, internet connectivity quality, institution type, availability of the institution's proprietary Learning Management System (LMS), and students' adaptability levels [2].

I find this dataset particularly intriguing due to its coverage of demographic details, technological access, and facets relevant to the online learning experience. The dataset is limited in that it does not contain any interval or ratio data points, but the insights gleaned from researching the provided nominal (such as gender or institution type) and ordinal values (such as age or class duration) have the potential to enhance the online learning experience for both students and educators alike. From this dataset, I intend to address the following research questions:

1. How do different socio-demographic factors influence the adaptability level of students in online education?
2. What are the primary barriers to online education faced by students in developing countries like Bangladesh?
3. How can educational institutions better support students in adapting to online learning environments?

Data Preparation:

The dataset contains 1,205 entries, with each cell holding a clean value. The dataset has previously been cleaned by the original researchers, streamlining all future analysis. The data was originally captured to train a machine learning model to predict how well students would adapt to an online educational environment. This research interest became particularly relevant during COVID-19 and is now commonly used as a reference point for similar studies.

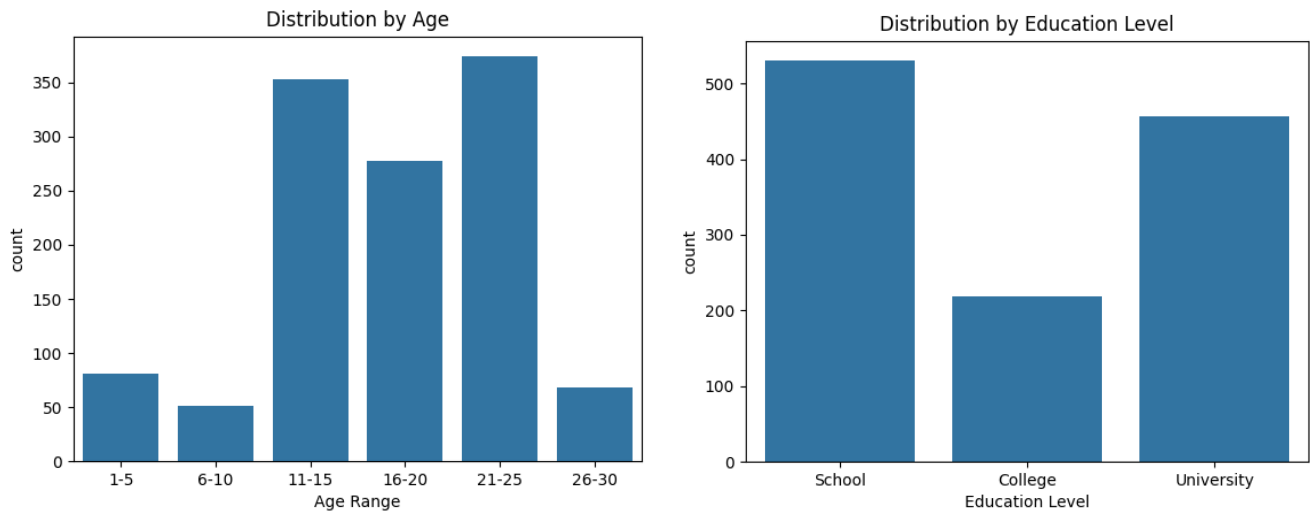
For instance, an essay titled, “Assessment of learning parameters for students' adaptability in online education using machine learning and explainable AI.” uses this data to create an alternative prediction model [3]. While the predictive results for both models seem to be relatively similar, it isn't odd that these researchers selected a previously existing dataset rather than collect the data themselves. Although they are limited to results which remain specific to this small sect of Bangladesh students, it's a great convenience to have such a dataset available.

One of the greatest barriers to conducting studies like this is data collection. Administrative datasets often have missing data due to unanswered questions by respondents or technical issues in data entry and linkage. While methods for inputting missing data exist, none are robust enough to be considered a gold standard [6]. It would be ideal to access an anonymous code that uniquely identifies a student. This code would allow for the construction of a panel dataset, tracking different student cohorts over time, and matching different sources of administrative data, even across multi-level educational institutions.

Of course, there needs to be a delicate balance between harnessing the power of data analytics in education and ensuring the privacy and trustworthiness of student data and assessments. To simplify matters, data collection for this particular dataset involved both online and in-person surveys, conducted in the Bengali language. To facilitate subsequent analysis, the collected data was manually translated into English. The researchers employed graphical representations, including bar and pie charts, to visually portray adaptability levels across different age groups and educational levels, encompassing schools, colleges, and universities.

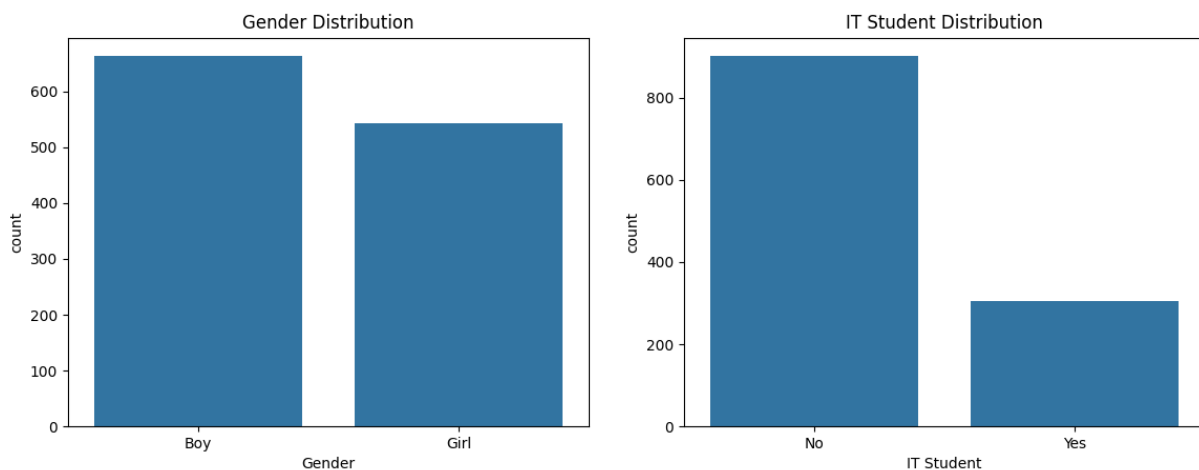
Data Exploration:

Before I start searching for correlations within the data, I will identify the distributions within the dataset using SQL and Python, starting with age. It comes as a surprise that none of the students are above the age of thirty, and even more of a surprise that some students are as young as five years old. The age distribution indicates that the majority of the students fall within the 11-20 age range, with the 16-20 category being the most populous. The 1-5 and 26-30 age ranges are the least represented in the data. This distribution could reflect the target demographic for online education or might indicate that these age groups are the most engaged with online education.

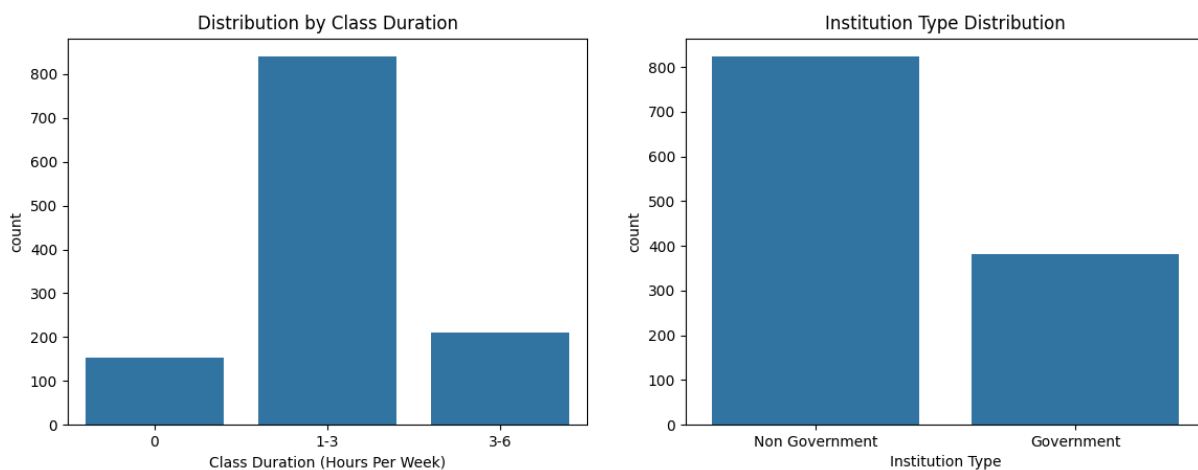


Similarly the distribution of age, students at the School level constitute the largest group, followed by those at the University level, with College students being the least represented. This could imply that online education is more accessible or more commonly used at the school and university levels compared to colleges. For those who do not see a differentiation between "college" and "university", these terms refer to the types of institutions of higher education, and the distinction between them can vary depending on the country.

In Bangladesh, the term "college" often refers to institutions that offer higher secondary education (grades 11 and 12) leading to the Higher Secondary School Certificate (HSC), and sometimes tertiary education up to bachelor's degree level. These colleges may be affiliated with a national university but do not have the authority to confer or award degrees on their own. Universities, on the other hand, are autonomous institutions regulated by the University Grants Commission, providing undergraduate and postgraduate education, and have the authority to confer degrees. Public universities are heavily subsidized by the government and are typically more competitive, focusing primarily on academic credentials for admissions. Private universities, which are more numerous, receive no government subsidies and have more flexible admission criteria, including a larger international student and faculty body.

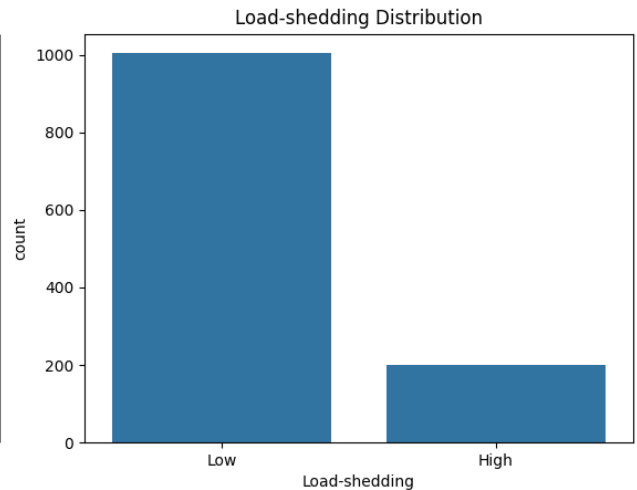
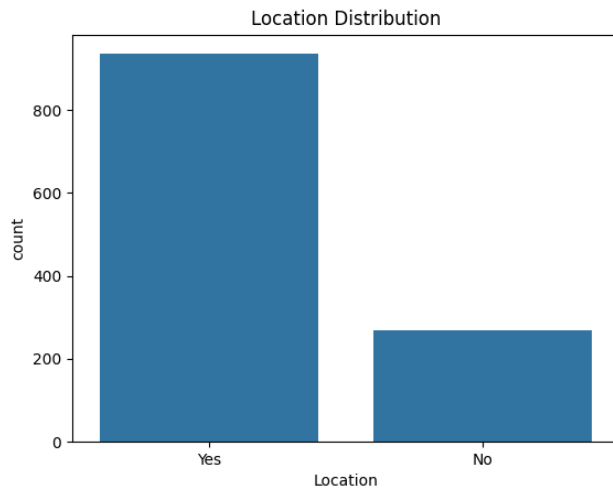


The gender distribution is nearly balanced, with a slightly higher count of boys than girls. This near parity suggests that there is relatively equal access to online education across genders in the sample, although the slight male dominance could warrant further investigation to ensure equitable access. Looking at the distribution of IT students, it's clear that a majority of students are not academically focused on technology. The lower number of IT students indicates that the dataset includes a broader range of academic disciplines, showing that online education is not limited to technology-oriented students. It might also suggest that IT-related courses have different adaptability requirements or that IT students use alternative resources beyond the scope of this dataset.



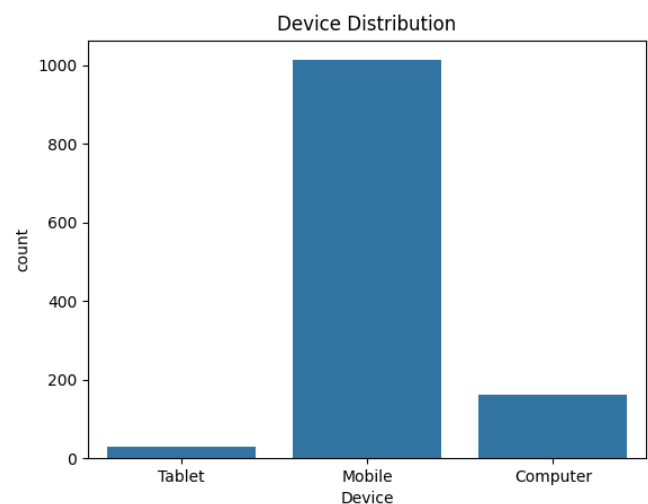
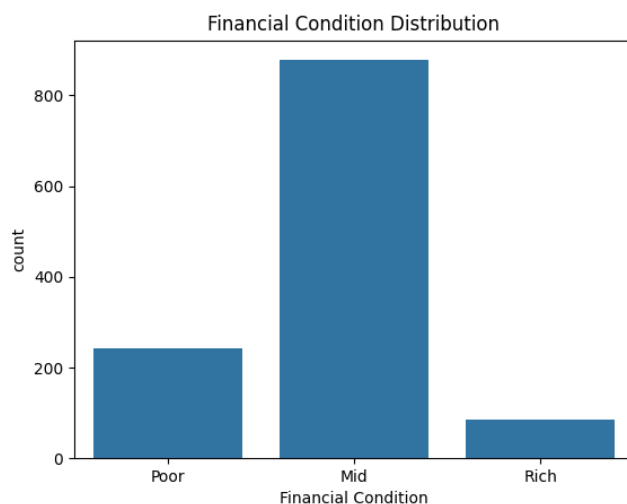
The distribution by class duration highlights a notable trend towards shorter online class sessions, with the majority of students having 1-3 hours per week. This concentration in shorter classes could speak to the evolving nature of online education, where brevity aligns with the need for flexibility and the challenges of maintaining student attention in a virtual environment. It also reflects on the course structures that educational institutions adopt, possibly aiming to accommodate diverse student schedules or pedagogical strategies optimized for online delivery.

In contrast, the institution type distribution reveals a skew towards private, non-government institutions, indicating a possible sectoral shift in education delivery. The prevalence of students from private institutions may suggest a dynamic response to the growing demand for online education, where such institutions are potentially capitalizing on their ability to innovate and adapt more rapidly than their government counterparts. This could be due to varying levels of bureaucracy, funding, and mission focus between government and non-government institutions, with the latter possibly offering more specialized or technologically integrated programs that attract students in an increasingly digital world.



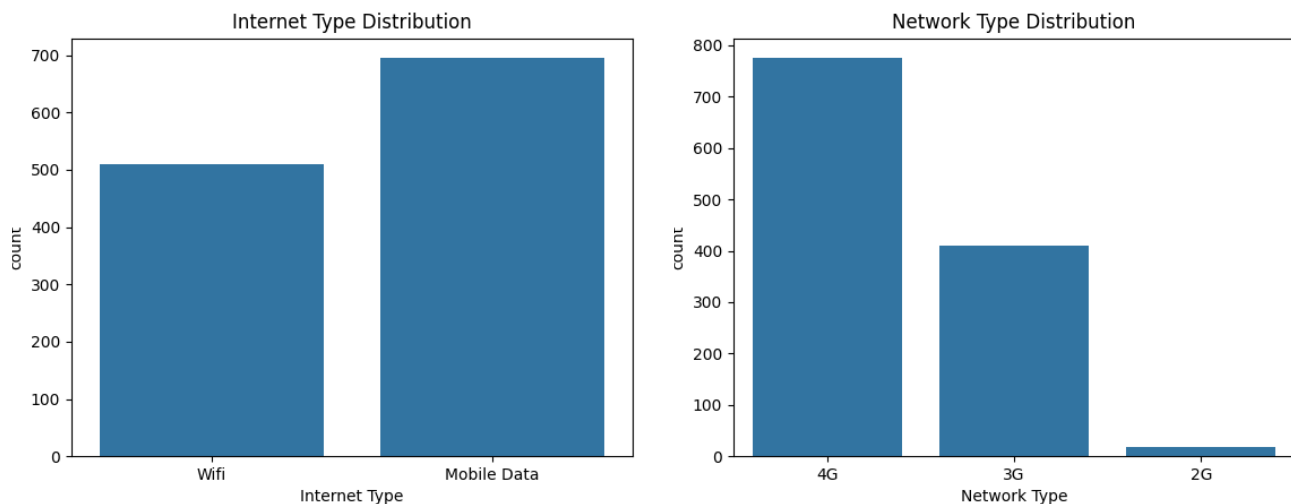
The location distribution reveals that most students have physical access to their educational institutions, local to Bangladesh. This access is a significant advantage, as it allows for a blended approach to education. Students can benefit from the resources and support systems available at their physical campuses, which may include internet access, study materials, and direct interaction with faculty. Such resources can enhance the online learning experience and provide a safety net for those who might otherwise struggle with the demands of a fully online curriculum. In a country like Bangladesh, where digital divides can be pronounced, the ability to utilize institutional resources can play a pivotal role in ensuring that students remain engaged and supported in their educational pursuits.

Concurrently, the distribution concerning load-shedding is particularly telling. With the majority of students experiencing 'Low' load-shedding, there is an implication of relative stability in the power supply, which is a critical infrastructure component for enabling consistent access to online education. In areas where load-shedding is prevalent, students' ability to participate in online learning can be significantly hindered, leading to disruptions that can affect the overall learning experience and outcomes.



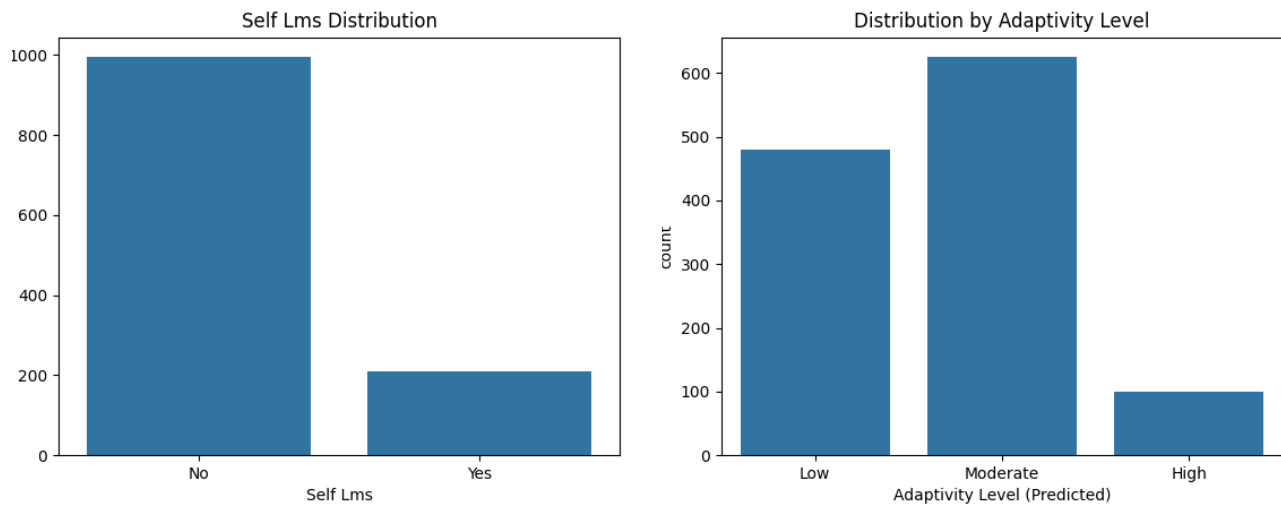
The financial condition distribution paints a picture of a student body rooted in the middle class, with fewer from the 'Rich' category. This pattern may reflect broader societal structures, where the middle class has adequate resources to engage in online learning, while the representation of 'Rich' suggests either a choice for different educational settings or a smaller proportion of the affluent within the surveyed demographic. These financial conditions can dictate the quality and frequency of online educational access, as they directly impact the students' ability to procure necessary technologies and stable internet services.

In Bangladesh, a country where socioeconomic status greatly influences educational opportunities, the device distribution insight is critical. The overwhelming preference for mobile devices might be closely tied to the economic fabric of society, where the cost-effectiveness and ubiquity of smartphones make them a natural choice for students. Moreover, in the face of load-shedding, the mobile device's resilience—thanks to battery life and wireless connectivity—ensures that students can maintain access to educational content, making it a practical tool for online learning continuity.



The Internet Type Distribution showing a preference for 'Mobile Data' over 'Wifi' could be indicative of the infrastructural realities in Bangladesh, where mobile internet is perhaps more reliable or more widely available than broadband services. Students' reliance on mobile data might also stem from the necessity of maintaining educational continuity amidst frequent power outages, as mobile networks provide an independent power source.

Meanwhile, the Network Type Distribution underscores a significant adoption of '4G' technology, showcasing that students have access to the higher-speed internet necessary for participating effectively in online education. The waning use of '3G' and '2G' networks aligns with a global trend towards faster connectivity solutions, which are better suited to the multimedia content and interactive platforms used in modern online learning environments.



The Self LMS Distribution reveals that a significant number of students are not utilizing self-learning management systems. A self-learning management system (LMS) is a digital platform that facilitates the management, delivery, and measurement of an educational process. Unlike traditional LMS platforms that are often managed by educational institutions, a self-LMS is typically used by individuals to manage their own learning.

Students use a self-LMS to access learning materials, track their progress, set learning goals, and take assessments. Teachers can use these systems to provide resources, monitor student progress, and offer feedback outside of traditional classroom settings. A self-LMS promotes autonomous learning by providing tools that support self-paced, personalized education, often incorporating features like forums, chat, and multimedia content to enrich the learning experience.

The Adaptivity Level Distribution showing a majority of students with 'Moderate' adaptability levels suggests a balanced approach to online learning, with most students being able to meet the learning objectives adequately. The smaller proportion of students with 'High' adaptability could indicate a need for more challenging or advanced materials, while those with 'Low' adaptability might benefit from additional support to enhance their online learning experience.

As we prepare to delve deeper into the data, the distribution charts have set the stage, revealing the multifaceted profiles of students engaging in online education in Bangladesh. The age distribution underscores the youthful skew of the student body, with a surprising representation of very young learners, possibly reflecting early exposure to digital education. The institutional distribution points to a potential shift in educational preferences, with private institutions possibly offering more adaptive online platforms.

These initial observations suggest varying degrees of accessibility and adaptability influenced by socioeconomic factors, technological infrastructure, and institutional support. The next step will be to examine how these variables interplay to affect students' adaptability to online learning.

We'll look for correlations within the data to identify patterns and relationships, aiming to answer pressing research questions about the barriers to online education and how institutions can better support students.

Through a nuanced analysis, considering the prevalence of mobile device usage in the face of power instability and the reliance on fast mobile networks, we'll strive to understand the adaptability levels within this digital education landscape. These insights will be crucial for crafting strategies that address the educational needs and barriers faced by students in Bangladesh, ultimately guiding enhancements to the online learning experience.

Data Analysis:

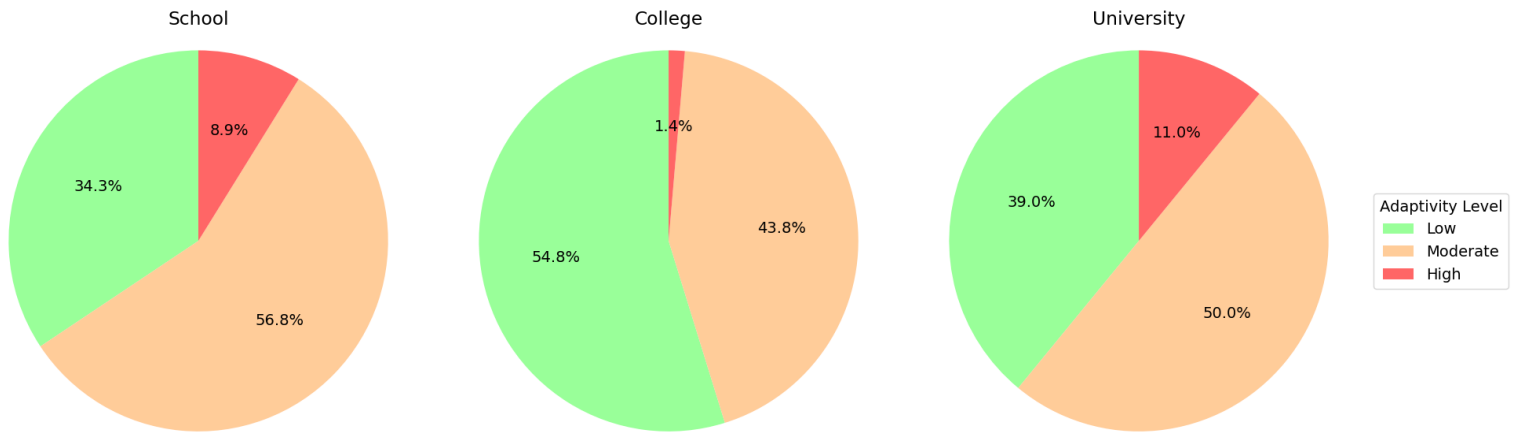
Now, I will begin to analyze the data, following my three primary research questions:

1. *How do different socio-demographic factors influence the adaptability level of students in online education?*

To fully address this question, a thorough investigation combining both statistical analysis and contextual understanding is required. This inquiry aims to discern the impact of various socio-demographic characteristics, such as gender, age, education level, institution type, financial condition, internet accessibility, and geographic location, on a student's ability to effectively engage and benefit from online learning environments.

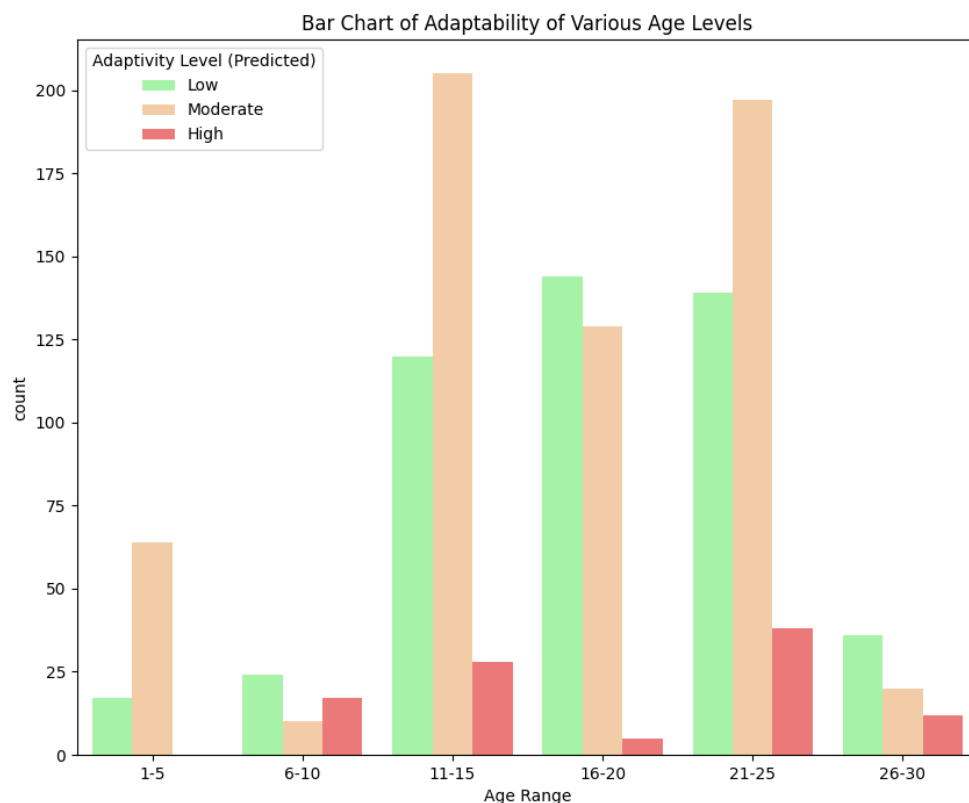
Various visualizations can be used to elucidate these relationships. Bar charts are instrumental in showing how adaptability levels vary across different categories of each socio-demographic factor. Box plots can offer deeper insights into the distribution and central tendencies of adaptability within each demographic category, which is particularly useful for ordinal data such as age groups or education levels. Heatmaps could be employed to visualize correlations between different factors and adaptability levels, especially if a composite adaptability score is created. For continuous variables, scatter plots can help in visualizing correlations with adaptability levels. Additionally, if regression analysis is conducted to quantify the influence of these factors, plots depicting the regression line and confidence intervals would be highly informative. Facet grids also offer a valuable tool for simultaneously comparing trends across multiple categories, such as adaptability level by age and gender.

I first wanted to mimic two visualizations made by the original researchers who created the dataset for their paper, "Students' Adaptability Level Prediction in Online Education using Machine Learning Approaches." More specifically, I mimicked a set of pie charts depicting the students' adaptivity at different education levels as well as a bar chart depicting the students' adaptivity at different ages [2]. These plots serve to demonstrate the range of students who are represented by the dataset, at different levels of intellectual development and academic pursuit.



The pie charts provide insight into the adaptability levels across different education stages. At the school level, a majority of students show a 'Moderate' level of adaptability, which may reflect an adaptability to online learning that is still developing. The 'High' adaptability is the least represented, suggesting room for growth in optimizing online education for younger learners. It's possible that course content at the school level is less advanced, making the online environment more adaptable. It's also possible that students at the school level have better resources available to support the very young students' transition to an online environment.

At the college level, adaptability levels are similar to the school level, with a majority at 'Moderate'. However, the 'Low' adaptability is significantly less than the 'High', indicating better engagement or resources that cater to the needs of these students compared to the school level. University students show the highest 'High' adaptability, which could be due to more advanced self-learning skills, higher motivation, or better access to resources that support autonomous learning. The presence of mature learners at this stage, who may have developed more effective learning strategies could also contribute to this pattern.

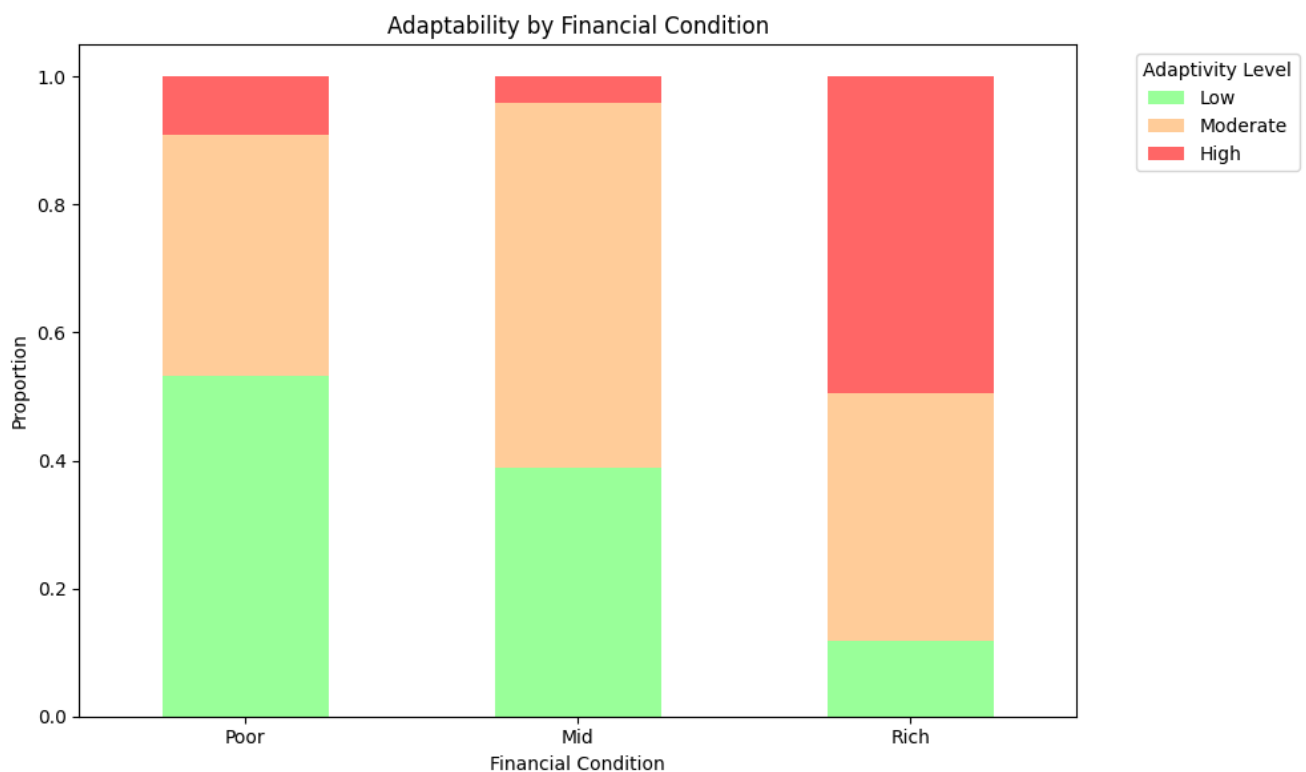


The bar chart of adaptability across various age levels shows an interesting trend where the majority of students in the 11-20 age range, which generally includes high school and undergraduate students, have a 'Moderate' level of adaptability. This suggests that students within this age bracket may have developed sufficient digital literacy skills and learning strategies to adapt to online education, but there may still be room for improvement.

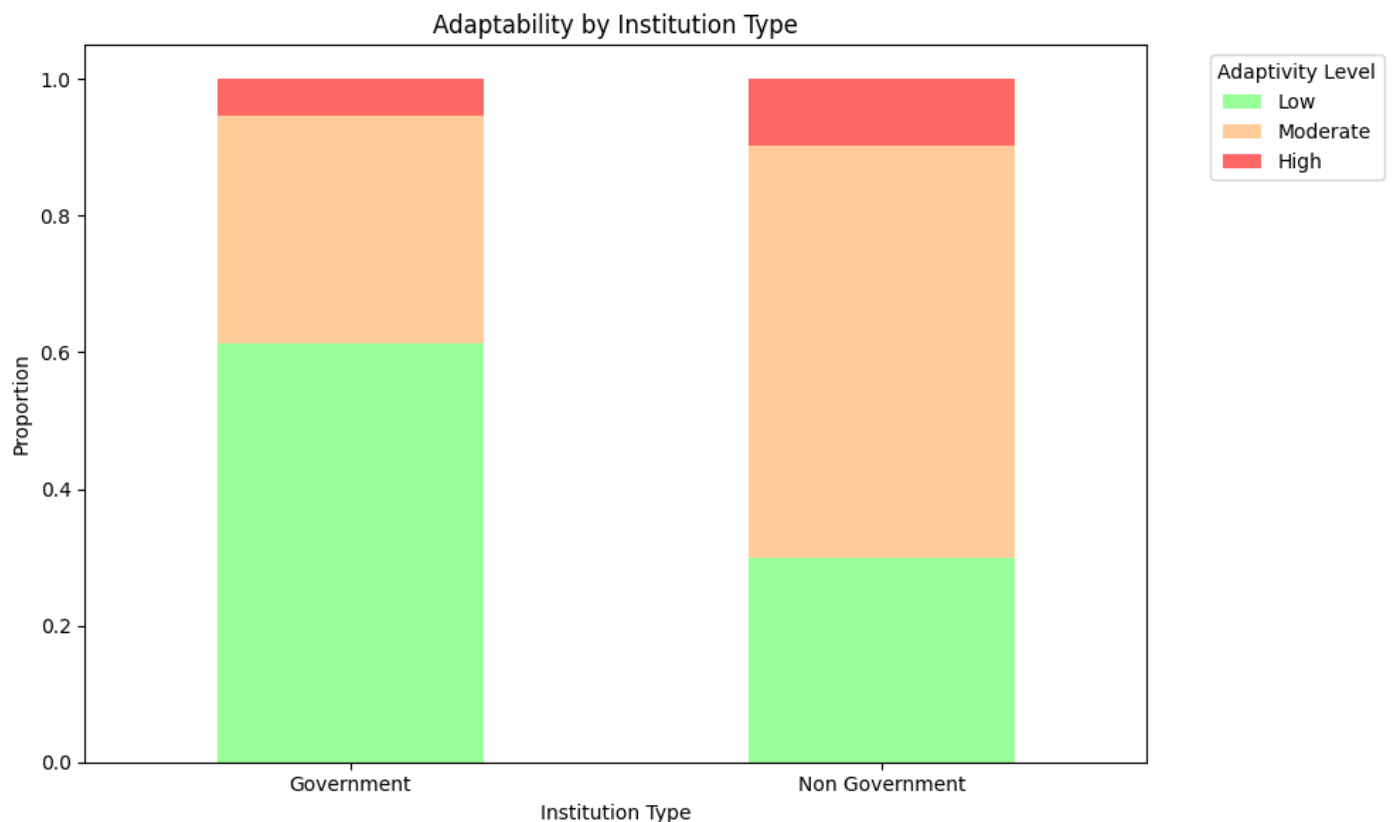
The 21-25 age group, in particular, shows the highest adaptability counts across all age groups, indicating that this age group is the most engaged with online learning. It's also noteworthy that the 'Low' adaptability level is still prominent, even though the oldest age group (26-30) may have a greater familiarity or comfort with online learning platforms or perhaps better self-regulation skills that come with maturity.

The distribution suggests potential areas where additional support could be beneficial, such as the age groups 1-5 and 16-20, where adaptability is lowest compared to the age groups they're neighboring. These findings can inform targeted interventions to improve adaptability, such as integrating more interactive and engaging content for younger students or providing additional technical support and resources.

To continue this analysis further, I want to introduce several more charts, focusing on the following demographics: institution type, financial condition, internet accessibility, and geographic location. My assertion posits that students in possession of enhanced financial means, superior technological access, and heightened connectivity, concurrent with their enrollment in private educational institutions, are inclined to manifest a greater degree of adaptability. Upon a thorough examination of the outcomes depicted in the subsequent graphs, it becomes apparent that a discernible correlation exists between socio-demographic factors and adaptivity

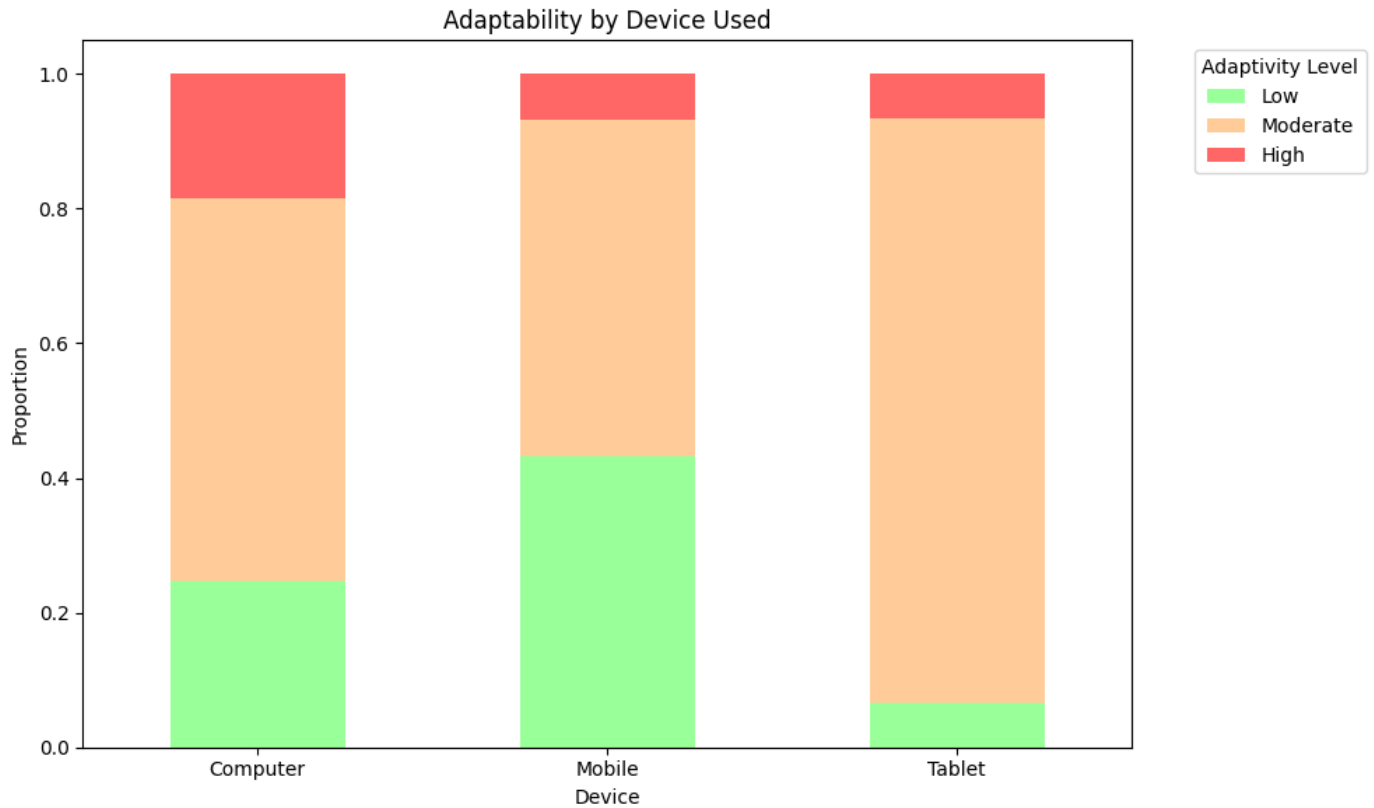


Right off the bat, it's clear a correlation exists between financial condition and adaptability. As the stacked bar graph indicates, students in the 'Rich' financial category exhibit the highest proportion of high adaptability, which decreases progressively through 'Mid' to 'Poor' financial categories. The financial condition may correlate with the ability to afford better-quality devices and internet services. Relating this to institution types, it would be worth exploring whether students with better financial standing are also those attending private institutions, which could have better online learning support and resources, hence contributing to higher adaptability.

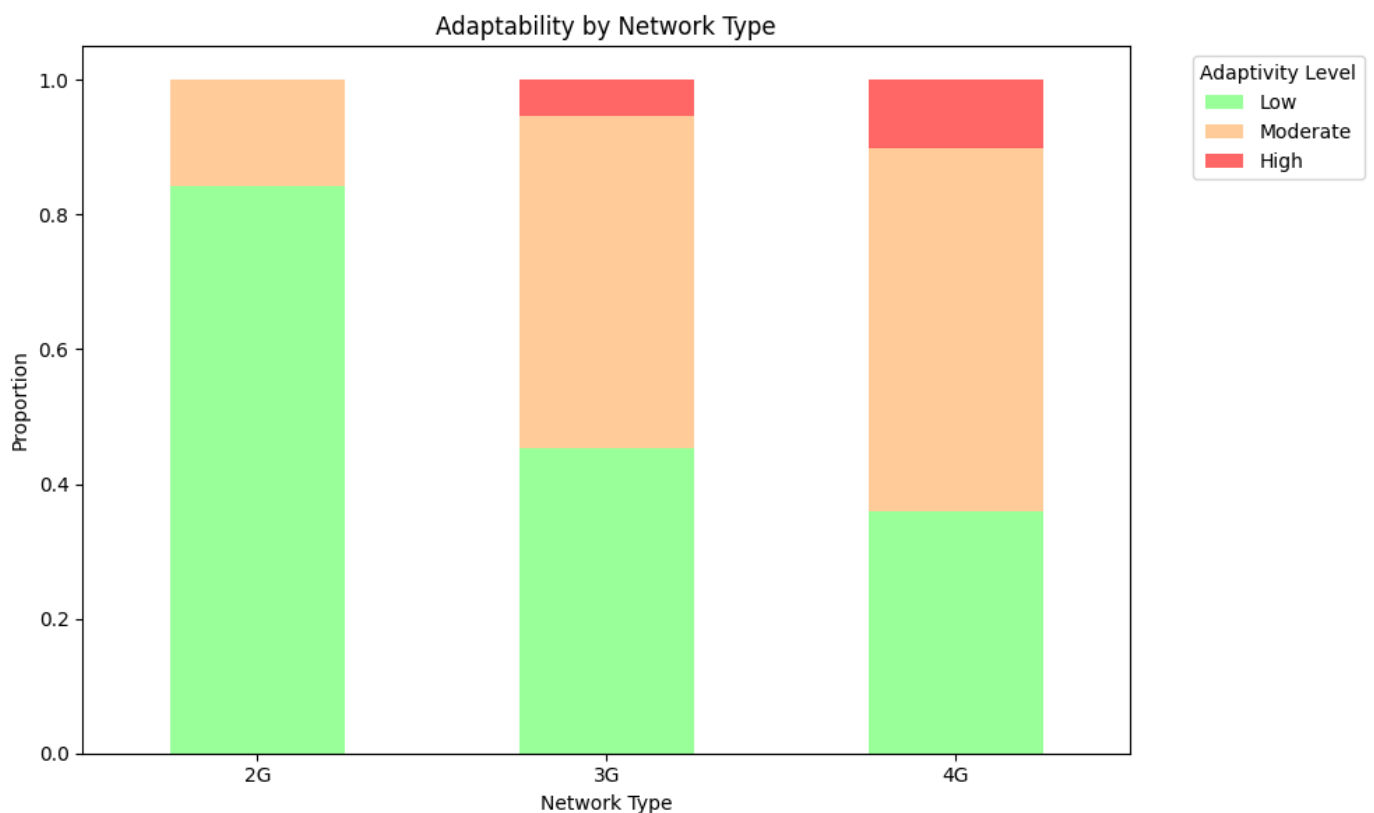


Private institutions (Non-Government) show a greater proportion of students with high adaptability levels compared to Government institutions. This could reflect differences in resources, teaching methods, and technological infrastructure available to students. It's possible that private institutions may have more funds, potentially from higher fees paid by students from better financial backgrounds, to invest in online education tools and platforms, thus enhancing adaptability.

I would expect that 'Rich' students would attend more private institutions, since these often cost money to attend unlike a 'Government' (public) institution which are usually free. Besides the benefit of having access to better educational tools at a 'Non-Government' institution, does having access to better technology and connectivity also see the same effect? I would expect this inference to be true.



The stacked bar graph above shows that students using tablets have the highest proportion of adaptability, followed by those using computers, with mobile users having the least. This trend could suggest that the functionality and ergonomics of tablets, possibly bridging the portability of mobiles and the usability of computers, may facilitate a more effective online learning experience. When cross-referenced with network types, it could be interesting to note whether tablet users generally have access to more stable networks like WiFi, which could contribute to their higher adaptivity levels.



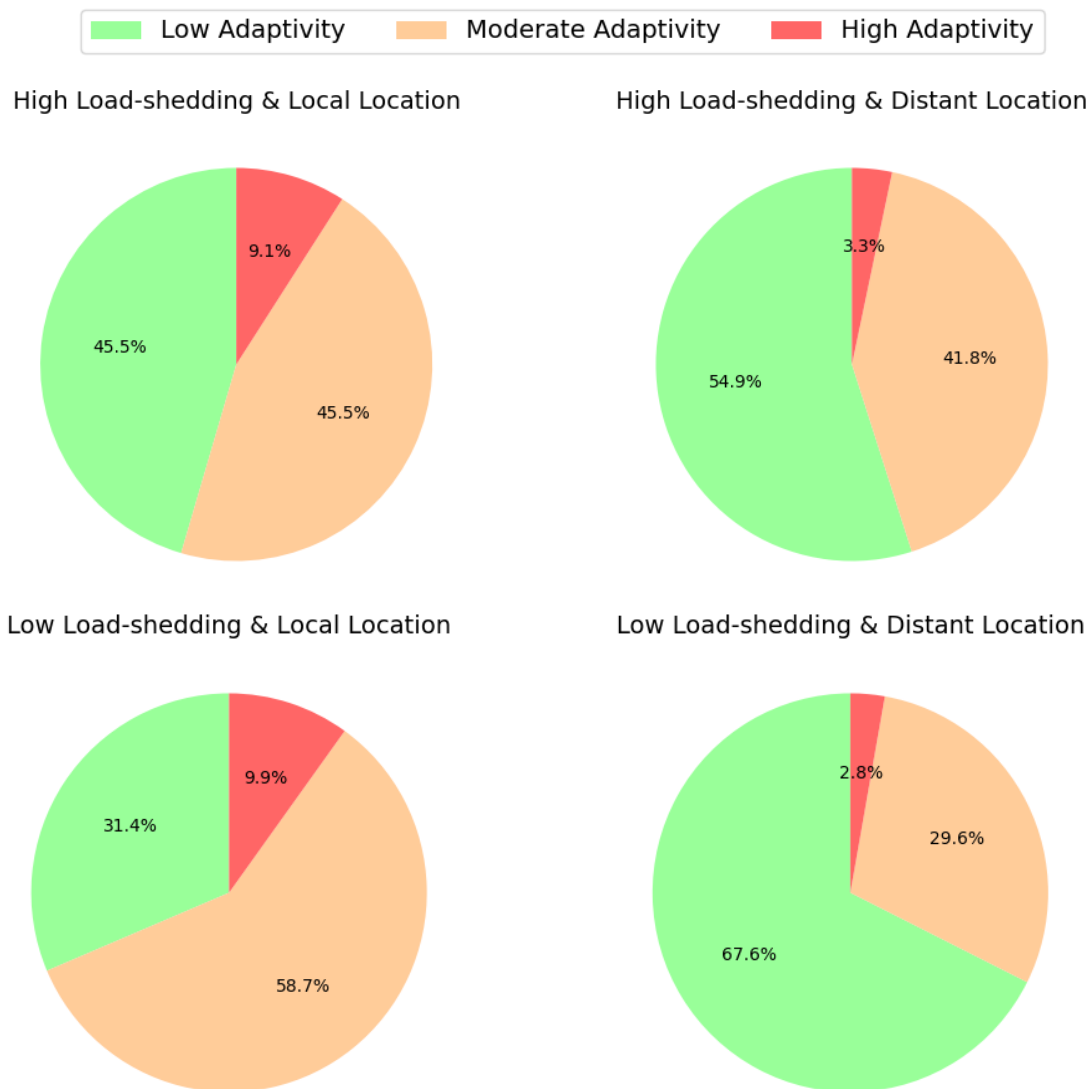
Similarly, the proportion of students with high adaptability is greatest amongst those with access to 4G and 3G networks, showing a decrease with each lesser speed of network. This suggests that better network connectivity enhances the online learning experience, possibly through faster access to learning materials and smoother communication with educators. Device type might play a role here too; for instance, computers may more often be used in environments with a stable WiFi connection, which could help explain the higher adaptivity seen with this device.

In the domain of virtual education, the interplay between network capabilities and device functionality emerges as a pivotal factor in facilitating an effective learning environment. Students encumbered by suboptimal internet speeds or utilizing devices that are not tailored to the demands of online educational platforms may encounter substantial impediments. These hindrances are often rooted in technical constraints that preclude full engagement with digital course materials, especially those that are multimedia-intensive or interactive in nature.

Furthermore, the architecture of online educational spaces frequently exhibits an inherent bias toward landscape-oriented devices, predominantly computers, given their widespread use in design and development processes. This orientation bias can render navigation and content interaction less intuitive on devices with portrait orientations, which are commonly smaller and lack the screen real estate of their landscape counterparts. Tablets, however, offer a compromise of versatility, straddling the line between portability and functionality. Their adaptive design allows for toggling between landscape and portrait modes, thereby mitigating some of the limitations faced by exclusively portrait-oriented devices and offering a better educational experience.

Similarly to a student's financial condition, I would expect that load-shedding to greatly impact students' ability to adapt well to an online educational environment. This is due to the depleted access that students might have to online course materials and other extenuating circumstances. I am not the only person who sought to find such a correlation, however. The paper titled, "Assessment of learning parameters for students' adaptability in online education using machine learning and explainable AI" delves into exactly that, but what they found was that load-shedding does not impact a student's adaptability level by much [3]. I created my own set of comparative pie charts (on the next page) that offer a nuanced perspective on the adaptivity levels of students in online education, stratified by the frequency of load-shedding and the geographic locality of the student (local vs. distant).

The pie charts on the next page illustrate the impact of load-shedding and location on adaptivity. Students residing in local or urban areas with low load-shedding predominantly exhibit moderate adaptability (58.7%), with a notable proportion demonstrating low adaptability (31.4%), and the highest fraction of high adaptability (9.9%) compared to the rest of the charts. This distribution suggests that while students in these areas may be hampered by power outages, other factors might be at play that promote a higher level of adaptability, which could include greater access to high-speed internet or educational resources.



In contrast, students from distant or rural locations experiencing low load-shedding show a starkly different profile, with the majority (67.6%) falling into the low adaptability category. The chart also shows the lowest amount of high adaptability (2.8%) and moderate adaptability (29.6%) out of the rest of the charts. This might be indicative of additional challenges inherent to remote locations, such as reduced accessibility to educational infrastructure and support services, which are not completely mitigated by the reduced frequency of load-shedding. There's also the possibility of a language barrier or time-zone clash, which may inhibit communication with classmates and instructors, or attendance in online lectures.

The scenario shifts when analyzing students from local areas with high load-shedding, where there is an equal proportion of students with moderate and high adaptability levels (45.5% each), and a minimal segment with low adaptability (9.1%). It's clear that locality presents a higher chance of high adaptability than distant online students. While, frequent power outages have less of an impact on student adaptability which could reflect the availability of compensatory resources or strategies that students might employ, such as utilizing battery-powered devices or accessing community centers with reliable power for online learning.

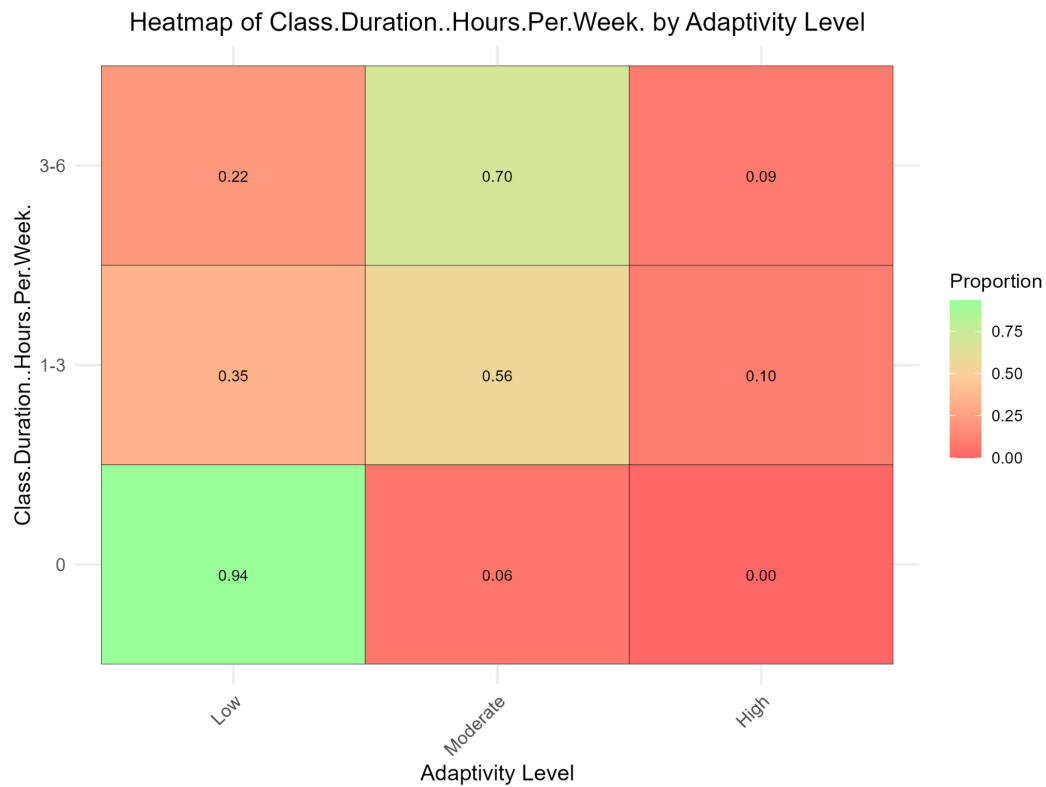
Furthermore, students experiencing higher rates of load-shedding may exhibit robust time management skills, scheduling their studies during power availability windows or employing resilience and adaptive strategies, such as pre-downloading study materials or using applications with offline functionalities. The chart, therefore, illustrates that adaptability to online education is multifactorial, influenced by a complex interplay of infrastructural, locational, and individual resilience factors. It underscores the importance of considering a broader spectrum of socio-environmental variables when assessing the adaptability of students in digital learning environments.

To conclude, the adaptability of students in online education is significantly influenced by a range of socio-demographic factors. Students from wealthier financial backgrounds and those attending private institutions generally exhibit higher adaptability levels, underscoring the crucial role of access to resources and quality educational support. The type of device and network connectivity also play pivotal roles, with tablets and higher-speed networks facilitating better adaptability, likely due to enhanced functionality and stable internet access. Age and education level further impact adaptability, with university students showing the highest adaptability, possibly due to more advanced self-learning skills and resources. Interestingly, geographical location and factors like load-shedding also contribute, but their effects are nuanced. Students in local areas with low load-shedding demonstrate higher adaptability, possibly due to better infrastructure, while high load-shedding does not significantly impede adaptability, suggesting that students may develop coping strategies. Overall, these findings highlight that adaptability in online education is a multifaceted issue, influenced by economic, technological, educational, and infrastructural factors. Addressing these disparities by enhancing resource availability and tailoring educational strategies to meet diverse student needs is crucial for improving adaptability across various student demographics.

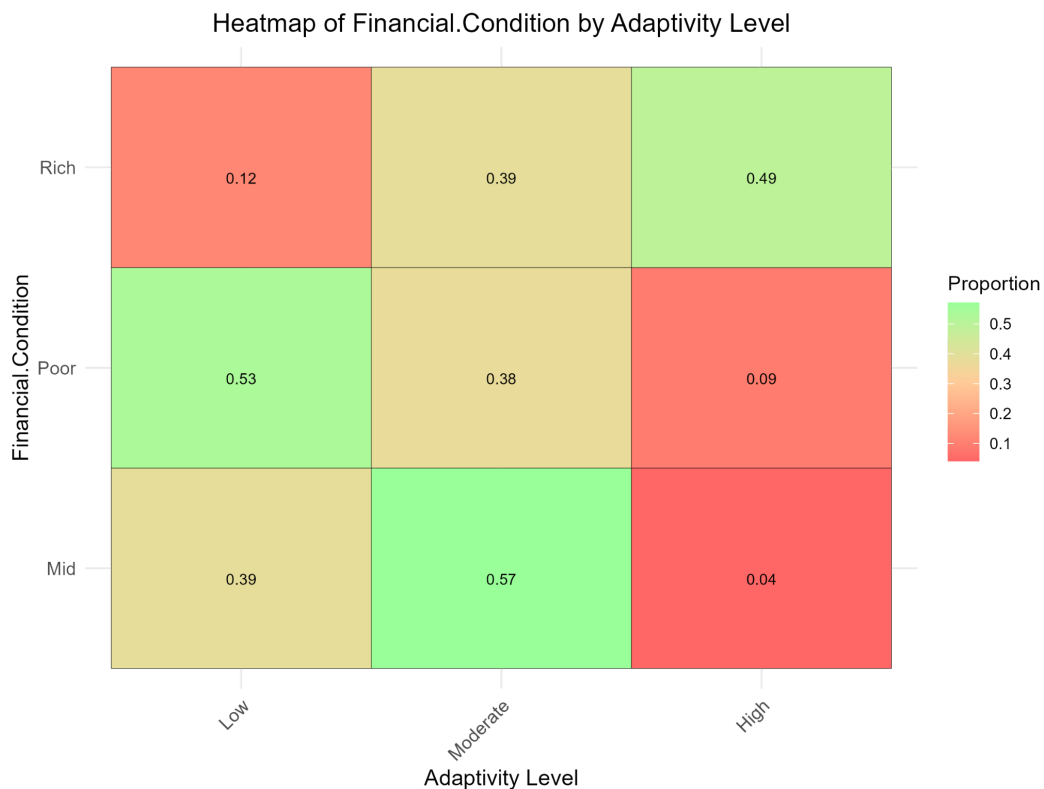
2. What are the primary barriers to online education faced by students in countries like Bangladesh?

To answer this question, I wanted to start by looking at the correlations between the various columns and each adaptability level. I used R to graph heatmaps, which represent the correlation of various factors with the adaptivity levels (low, moderate, high) of students in an online education context. The color scheme is designed to reflect the strength and direction of correlation: green for high positive correlation, orange for no or very little correlation, and red for high negative correlation.

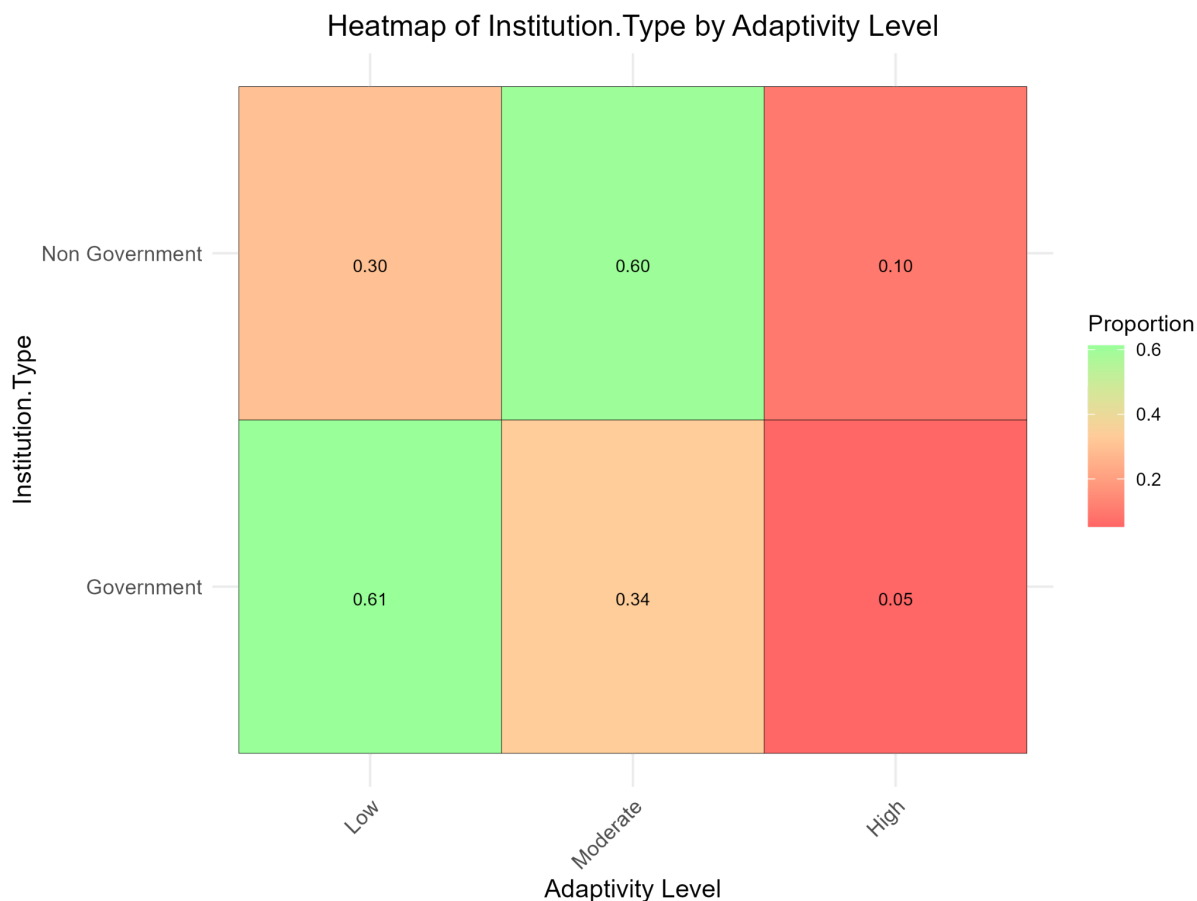
These heatmaps can help identify which factors are most associated with high adaptivity and, conversely, what may constitute significant barriers to effective online education for students in countries like Bangladesh. The primary barriers highlighted could include financial constraints, insufficient institutional support, lack of digital literacy, poor infrastructure, and geographic limitations. Each heatmap contributes a piece of the narrative to understand the multifaceted challenges faced in online education settings.



The Class Duration heatmap suggests that the number of hours dedicated to online classes per week correlates with adaptivity levels. An optimal range of study hours seems to contribute to higher adaptivity, indicating that both a deficiency and an excess of class hours could potentially hinder adaptivity. This insight implies that structuring online education with an appropriate duration is crucial; too little time may not cover the material sufficiently, while too much could lead to burnout.

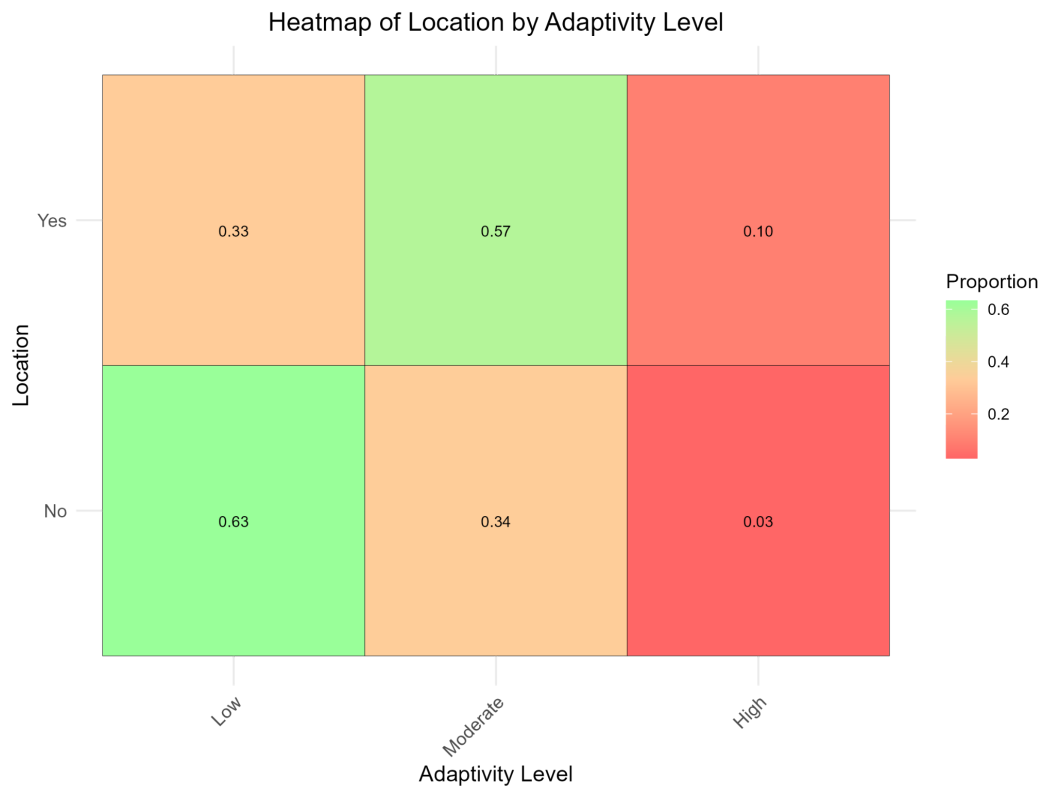


As expected, the Financial Condition heatmap provides a noticeable distinction in adaptivity levels based on students' economic backgrounds. Those from more affluent families likely have better access to resources, contributing to higher adaptivity levels. In contrast, students from less affluent backgrounds may struggle due to resource constraints. This highlights financial capability as a significant barrier, where affordability can dictate the quality and accessibility of online education resources.

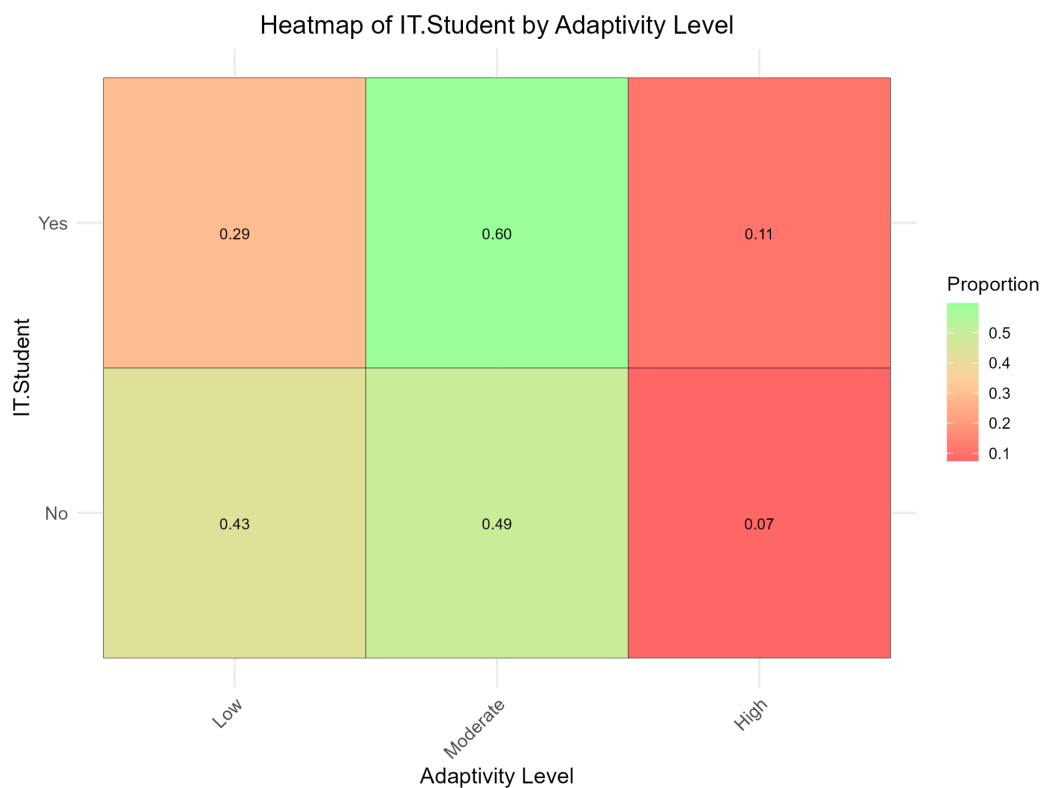


The Institution Type heatmap reveals the role of institutional support in adaptivity. There might be a disparity between the resources and support systems offered by government versus non-government institutions. The type of institution can thus be a determinant of adaptivity, suggesting that institutional policies and the quality of support provided are essential for effective online learning environments.

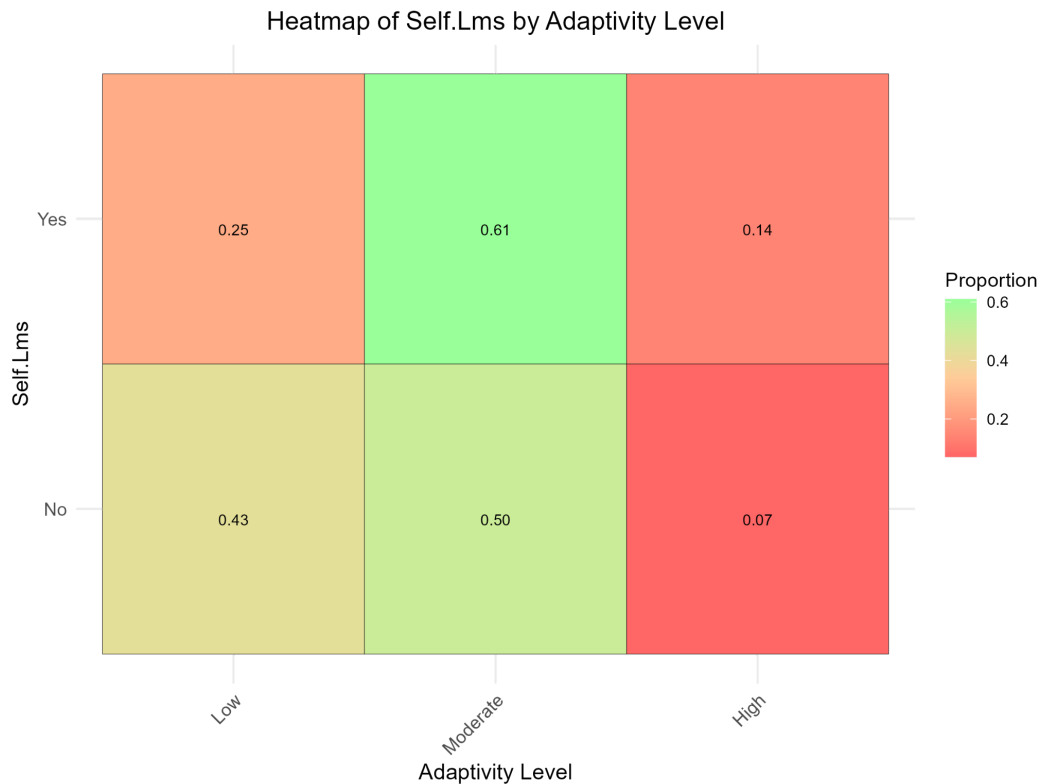
Through the Location heatmap, on the next page, we observe how geographical factors play into adaptivity. Students in local, urban areas may have better adaptivity due to improved internet connectivity and technology access, while those in distant, rural areas may face significant barriers such as poor internet infrastructure or suboptimal access to their institution's resources. This geographical divide underscores the need for equitable access to technology across different locations.



The IT Student heatmap indicates that students with an IT background exhibit relatively balanced adaptivity levels to non IT students, even due to their assumed proficiency with technology. Non-IT students may find the technical aspects of online education more challenging, pinpointing digital literacy as a barrier. Ensuring that all students, irrespective of their major, have the necessary technical skills is imperative for the success of online education.



Lastly, the Self Lms heatmap explores the impact of using Learning Management Systems on adaptivity. Familiarity with such platforms seems to correlate with higher adaptivity, suggesting that not being conversant with or having access to LMS tools can be a hindrance. The heatmap serves as a reminder of the importance of integrating effective digital tools into the learning process.



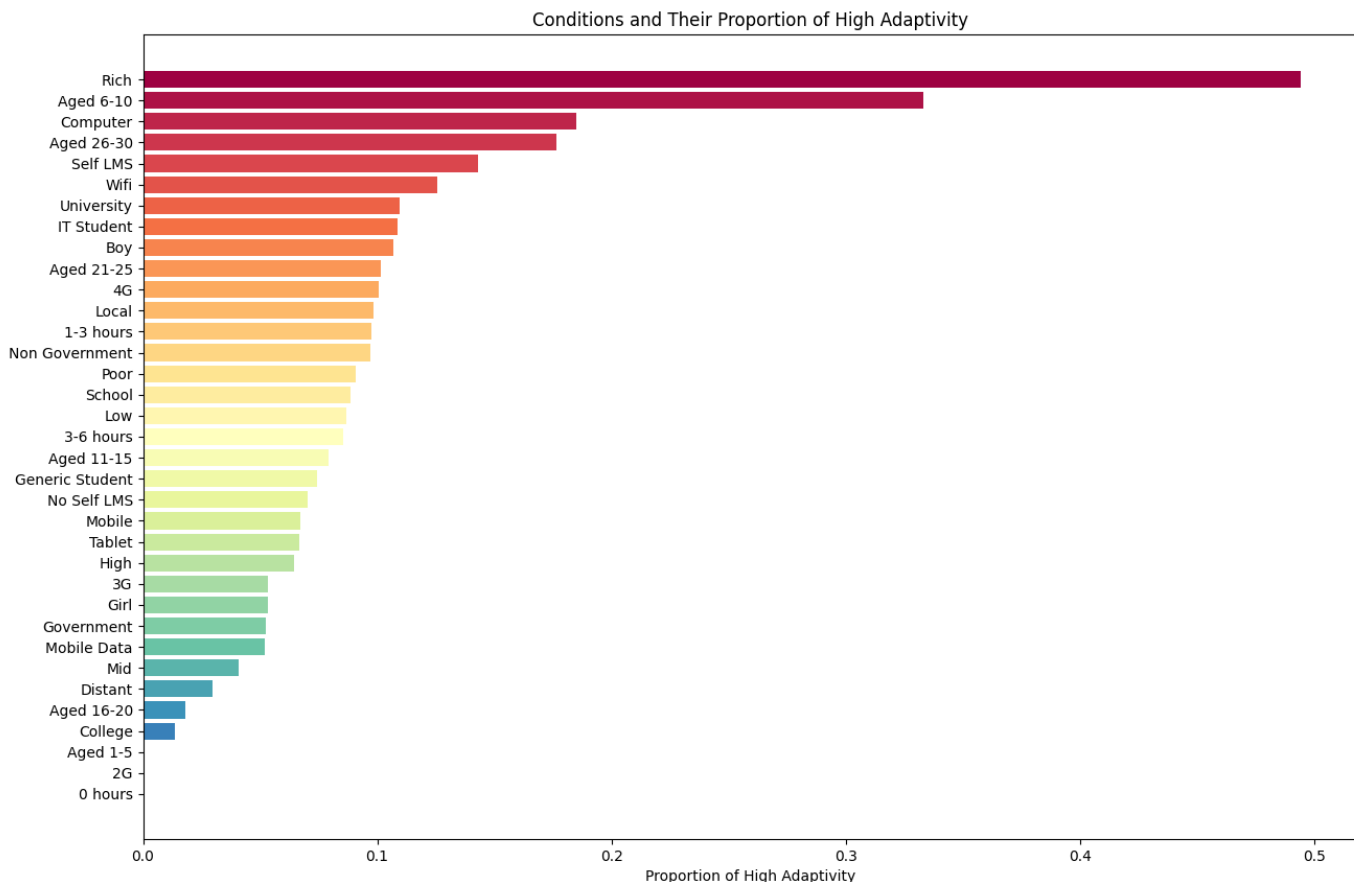
The insights gleaned from the heatmaps underscore that conditions most often associated with low adaptivity among students in countries like Bangladesh involve a complex interplay of socio-economic and infrastructural factors. The red zones in the heatmaps, indicative of high negative correlation, suggest that students who are financially disadvantaged, located in rural and distant areas, or lacking in digital infrastructure and literacy, are most at risk for low adaptivity in online education settings.

To address the question of primary barriers to online education, the visual data underscores that economic constraints are perhaps the most significant hurdle. Students from lower financial backgrounds frequently face multiple concurrent disadvantages that impede their adaptivity, such as limited access to reliable internet, fewer educational resources, and lack of supportive learning environments. Geographic disparities compound these challenges, as rural areas may not offer the same quality of internet service or institutional support as urban centers. Additionally, the transition to digital learning platforms, while beneficial in increasing accessibility, also presents a steep learning curve for those without prior exposure to such technologies.

In conclusion, the primary barriers to online education in Bangladesh are multifaceted, but disproportionately affect students who are economically underprivileged and geographically marginalized. Overcoming these barriers requires a concerted effort to improve digital infrastructure, democratize access to learning resources, and provide comprehensive support systems that can bridge the gap between diverse student populations and the evolving demands of online education.

3. *How can educational institutions better support students in adapting to online learning environments?*

This final graph takes the cake in observing what conditions determine high adaptivity. I designed it hoping it would provide an insightful visual breakdown of factors contributing to students' successful adaptation to online learning environments. The graph's horizontal bars represent various conditions, with the length of each bar correlating to the adaptivity level of students within those conditions.



As we've previously witnessed, economic status plays a pivotal role in adaptivity to online learning. The condition marked as "Rich" has the most extended bar, implying that students from affluent backgrounds are more likely to adapt well to online education. Age also seems to be a determinant factor, as seen by the significant adaptivity in the "Aged 6-10" and "Aged 26-30"

groups. This suggests that both the youngest learners, who may adapt quickly due to their educational environment, and adults who are likely to be self-motivated and have better self-regulation skills, find it easier to adjust to online learning modalities. These findings emphasize the need for age-specific strategies in online education, with a focus on engaging teaching methods for young students and flexible learning schedules for adults.

The bars corresponding to "Computer" and "Wifi" are notably longer, indicating that technological access is crucial for high adaptivity. This reinforces the idea that educational institutions must ensure that students have sufficient access to computers and a stable internet connection, which are foundational to their success in an online learning framework.

Learning management systems are also significant, as shown by the length of the bar for "Self LMS," highlighting the importance of students being able to navigate these platforms effectively. This points to the need for educational institutions to provide training and support in using LMS, which could help bridge the gap for students less familiar with such systems.

The comparison between "Non Government" and "Government" institutions suggests that the type of institution may affect adaptivity, with non-governmental institutions potentially offering more conducive or flexible environments for online learning. This could prompt a reassessment of the support structures within governmental institutions to foster better adaptivity.

Furthermore, the difference between "Local" and "Distant" conditions underscores geographical challenges. Proximity to educational resources often translates into higher adaptivity, indicating that students in remote or rural areas might lack access to the necessary infrastructure. This calls for an expansion of digital infrastructure into these areas and possibly the development of local support centers to aid distant learners.

However, the graph also reveals that conditions like "2G", "0 hours (of class time per week)" and age groups such as "Aged 1-5," have the shortest bars and, hence, are associated with low adaptivity. These are indicative of areas where educational institutions need to intervene proactively. Very young learners require specialized educational tools and methods tailored to their developmental stage, while students with inadequate internet services need infrastructural upgrades or alternative means to access online content.

In conclusion, the bar chart provides a comprehensive overview of the factors influencing adaptivity in online learning, particularly highlighting the impact of economic status, technological access, age, institutional support, online infrastructures, and geographic location. Educational institutions seeking to support students in adapting to online learning must address these critical areas. By doing so, they can help overcome the barriers that prevent students from fully embracing and benefiting from online education, thereby fostering an equitable and effective learning environment for all.

Discussion:

To enhance student adaptability, institutions need to address the impact of socio-demographic conditions. Utilizing modern tools like machine learning can predict and understand these factors effectively. The 2018 journal "Data Analytics Applications in Education" discusses data analytics' role in improving educational outcomes. It covers using analytics to enhance learning, provide real-time feedback, measure student and instructor performance, and discusses its implications and challenges in higher education [6].

This journal also explores how data analytics could reveal educational barriers and aid in developing more accessible educational tools and effective lesson planning. Key research questions include improving learning processes, the empirical evidence in education research, the impact of fraudulent student behavior on data, especially in online quizzes, and the systematic nature of review studies in disciplines like economics.

Data analytics, defined in the journal, includes various techniques from basic business intelligence to advanced predictive and prescriptive analytics. With the traceability of every online student action, these analytics can offer personalized, real-time feedback and learning paths.

Beyond student performance, data analytics can assess instructor effectiveness and predict future student outcomes, helping educators and policymakers optimize resource allocation and school performance monitoring.

The journal also addresses the challenges in data analytics, such as data collection, integration, and ethical concerns in using student data. Ensuring data integrity and understanding fraudulent behavior are vital for effective data-driven educational strategies.

The journal emphasizes evidence-based research in education, involving systematic review and experimental evaluation of interventions. It highlights the importance of rigor and quality in research for informed decision-making by educators and policymakers. Systematic reviews are crucial for a comprehensive and unbiased understanding of research topics, contributing to the relevance and usefulness of findings in education.

Using a cyclical process of inquiry and building new knowledge is a self-reinforcing process that begins by setting feasible learning goals. This involves teachers assessing their current knowledge and skills, identifying what new understanding is required, and implementing changes to achieve the goals they've set for their students. As depicted in figure 3.2, this method underscores the iterative nature of research, where practice is informed by data, and vice versa. Such a process fosters continuous improvement in teaching practices, allowing teachers to regularly evaluate and adjust their methods based on data and feedback. This approach ensures they effectively meet their students' needs and achieve desired learning outcomes.

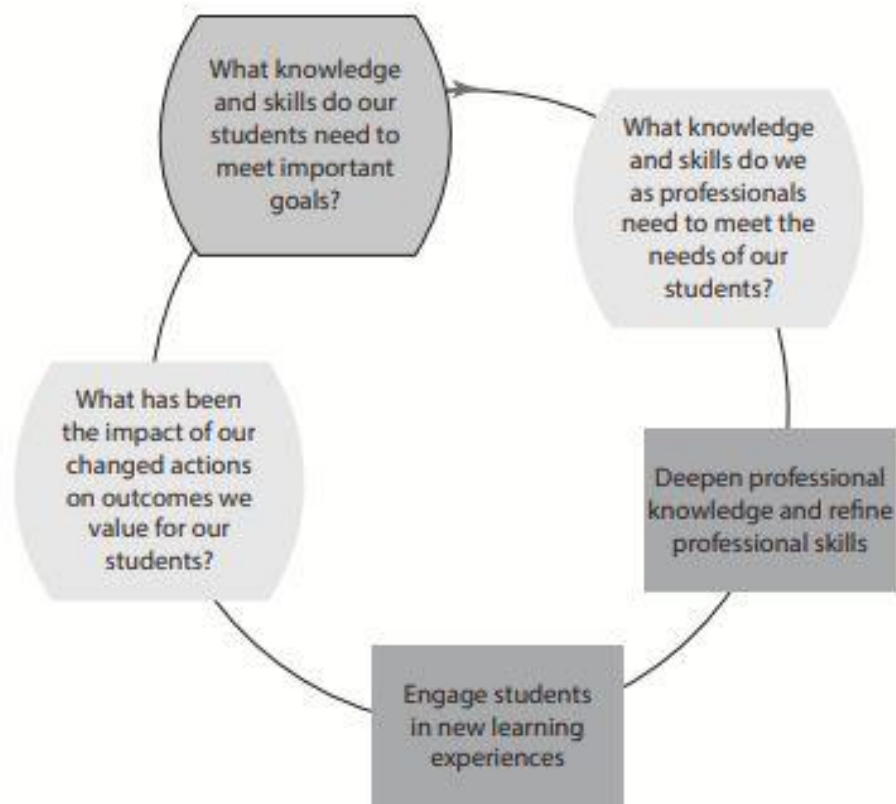


Figure 3.2 Teacher enquiry and knowledge-building cycle. (From Muijs, D., et al., *School Effectiveness and School Improvement*, 25(2), 231–256, 2014.)

This brings us to the question: how might a process like this address challenges such as load-shedding to enhance student adaptability? In Bangladesh, load-shedding is a prevalent issue that does impact students' ability to adapt to online education. As reported by The Business Standard, frequent power outages, sometimes up to five times a day, disrupt students' study schedules and the operations of educational institutions [7]. The lack of alternative power sources, such as Instant Power Supply (IPS) units, in most schools leads to frequent suspension of classes during outages, with no strategies in place to recover lost time.

Furthermore, the impact of load-shedding is exacerbated by heat, making it difficult for students to concentrate even when power is available. The government's area-based load-shedding strategy for managing energy subsidies affects educational activities nationwide. While some institutions have installed IPS units to sustain education during power cuts, others lack such facilities, revealing a disparity in resources and preparedness among educational establishments. This challenge is particularly acute for students preparing for critical exams like the SSC and HSC, as the delays and interruptions add to their stress and uncertainty.

So, why isn't this disparity more evident in the dataset? While load-shedding may not directly correlate with a student's adaptability as previously discussed, the combined factors of infrastructural limitations, resource disparities, and the consequent psychological and physical

discomfort significantly impede the educational experience in Bangladesh's online learning environments. Without additional support systems to counter outages, students would struggle to mitigate the impact of load-shedding. While machine learning mechanisms alone cannot directly address this issue, such data could incentivize institutional funding and welfare for students in financially challenging circumstances, ultimately supporting their adaptability and resilience in the face of these challenges.

The study "Adaptability to online learning: Differences across types of students and academic subject areas" delves into adaptability variations among diverse student groups and academic fields [4]. This research scrutinizes the adaptability of college students in online settings, particularly focusing on their perseverance and performance in online courses. It provides a comprehensive view of how adaptability varies among different student demographics and subjects, offering a valuable comparative lens to understand aspects possibly underexplored in your dataset.

Complementing this perspective is the study "Adaptability to a sudden transition to online learning during the COVID-19 pandemic" which offers a detailed examination of the specific challenges of student adaptability in this context [5]. This research delves into the difficulties students faced with the unexpected shift to online learning, focusing on their resilience and adaptability in these unprecedented circumstances, and identifying ways to overcome any potential barriers. Complementarily, "Students' Adaptability Level in Online Education" emerges as a significant contribution, composed several years post the onset of the global COVID-19 pandemic. This study offers insightful observations into the online learning environment, particularly noting the advancements in infrastructure that may have enhanced student adaptability in recent times.

Addressing the question, "how do different socio-demographic factors influence the adaptability level of students in online education?" are several key studies. For instance, "Assessment of learning parameters for students' adaptability in online education using machine learning and explainable AI" [3] focuses on the technical aspects of adaptability assessment. Though it does not directly delve into socio-demographic factors, its machine learning approach can be instrumental in uncovering patterns related to these factors in the dataset. Additionally, 'Adaptability to online learning: Differences across types of students and academic subject areas' [4] directly investigates adaptability variations among diverse student groups, likely encompassing socio-demographic elements.

The second question, "What are the primary barriers to online education faced by students in developing countries like Bangladesh?" is crucial in unveiling patterns that lead to low adaptability. The dataset, developed two years after the COVID-19 pandemic, captures a phase where students had predominantly adapted to online learning. The study "Adaptability to a sudden transition to online learning during the COVID-19 pandemic: Understanding the challenges for students" [5] offers insights that are likely relevant to developing countries,

highlighting shared challenges such as infrastructural inadequacies, resource deficits, and the necessity to adapt to new technologies.

Finally, the third question, “How can educational institutions better support students in adapting to online learning environments?” is addressed through various studies. The approach suggested in “Assessment of learning parameters for students' adaptability in online education using machine learning and explainable AI” [3] can help institutions identify student struggles and provide targeted support. Insights from the pandemic-era study [5] are also valuable for institutions to understand and address the challenges students faced during the sudden shift to online learning.

The surge in online education has led to a deeper exploration of student adaptability, as evidenced by the dataset on "Students' Adaptability Level in Online Education [1]." Three pivotal studies were analyzed in relation to this dataset. The first study leverages machine learning to assess adaptability factors [3], the second investigates adaptability variations across student demographics and academic disciplines [4], and the third offers insights into the adaptability challenges during the COVID-19 pandemic [5]. Together, these studies provide a multifaceted understanding of adaptability in online education, addressing key research questions about socio-demographic influences, barriers in developing countries, and institutional support mechanisms.

Conclusion:

This research has delved deeply into the adaptability levels of students in online education, particularly in the context of Bangladesh. The key findings highlight several critical factors influencing students' adaptability, including class duration, institution type, and financial condition. Contrary to initial expectations, load-shedding and whether students are IT-focused or not, do not significantly affect adaptability levels.

One of the central insights from this study is the stark disparity in online education adaptability based on socio-economic status. Students from financially stable backgrounds, typically attending private institutions, show higher adaptability. This underscores the role of resource availability and educational support quality in effective online learning. Conversely, those from less affluent backgrounds face considerable challenges due to limited resources, highlighting the need for targeted interventions to bridge this gap.

Technological access is a critical factor influencing adaptability. The prevalence of mobile devices and the reliance on mobile data, often driven by cost-effectiveness and resilience against power issues, underscore the necessity for educational strategies that accommodate these constraints. To address this, institutions must prioritize the provision of stable internet connections and technology that can facilitate effective online learning.

Moreover, when addressing these findings, educational institutions must adopt a holistic approach that considers the diverse needs of their students. This entails bolstering digital infrastructure to guarantee stable and consistent access to online education, particularly in regions plagued by frequent power outages or limited internet connectivity. Educational policies should be designed to ensure equitable access to resources, allowing students from all socio-economic backgrounds to fully access and benefit from online education.

Additionally, the adaptability to online learning is not solely dependent on technological factors but also on the pedagogical approaches employed by educational institutions. There is a need for curricula and teaching methods that are tailored to the online environment, catering to the varying needs of a diverse student body. This includes integrating interactive and engaging content, especially for younger students, and providing additional support for those who struggle with the demands of online learning.

In this academic report, I draw upon a personal anecdote which, though atypical, provides a unique lens to understand our global challenges. A friend of mine steadfastly believed that the solution to most of the world's problems lay in eradicating global poverty. Initially, I was skeptical, but over time, this perspective resonated with me, especially when considering the dynamics of resource access and its impact on global issues, such as war. The stark contrast between those who lack resources and those who have amassed them is striking. Those deprived of essential resources often find themselves in a position of disadvantage, struggling for basic needs and opportunities. Conversely, those who have accumulated resources wield significant influence and power over others.

This dichotomy brings me to the realization that solving a majority of the world's problems is more complex than just redistributing wealth. It's not merely about throwing money at issues but understanding and addressing the deeper, underlying causes. Poverty, at its core, is not just about the absence of money; it's about the absence of opportunities, education, healthcare, and empowerment.

Addressing these problems wisely means going beyond superficial solutions. For instance, while providing financial aid to the impoverished can offer immediate relief, it does not necessarily lead to long-term sustainability. The real solution lies in tackling the fundamental issues that create and perpetuate poverty. This involves creating equitable systems where everyone has access to quality education, healthcare, and opportunities for economic advancement.

In the context of online education, as explored in this report, the limitations faced by students in developing countries are a reflection of a broader issue of resource disparity. The challenges are not just technological but are deeply rooted in socio-economic conditions. To truly empower these students, it is not enough to provide them with laptops or internet access. The solution lies in creating an educational infrastructure that is accessible, inclusive, and adaptable to the diverse needs of all students, regardless of their socio-economic background.

Therefore, the journey towards solving world problems, including educational disparities, requires a holistic approach that addresses the root causes. It necessitates building systems that are equitable and sustainable, ensuring that every individual has the resources and opportunities to thrive. This approach may not offer quick fixes, but it promises more enduring and meaningful change.

In summary, the findings from this research illuminate the multifaceted nature of adaptability in online education. Addressing the barriers faced by students, particularly in developing countries like Bangladesh, requires a holistic approach that combines improvements in technological infrastructure, equitable resource distribution, and pedagogical innovation. By focusing on these areas, educational institutions can significantly enhance the adaptability and overall learning experience of students in online environments.

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