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## **Learning Computer Hardware by Doing: Are Tablets Better Than Desktops?**

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### **Abstract**

In this world of rapidly evolving technologies, educational institutions often struggle to keep up with change. Change often requires a state of readiness at both the micro and macro levels. This paper looks at a tertiary institution that undertook a significant technology change initiative by introducing tablet based components for teaching a hardware course across nine campuses in the United Arab Emirates (UAE) using a Learning By Doing (LBD) philosophy. This paper adopts a readiness for change model (RFC) as a method of evaluating the results from a case study that captured the readiness perceptions of both students and faculty. A survey revealed that, while faculty thought that introducing tablets was a good idea and that there was a high level of RFC, they also thought that the students would learn more about hardware from desktop kits. The students' responses also indicates a high level of RFC with many describing tablets as easier to work on yet they were divided about which technology was better for learning hardware concepts. In this context a high level of readiness for change, while supported by LBD, did not necessarily equate to improved learning and effective change.

**Key words:** Tablets; Readiness for change; Learning by doing; Teaching hardware

### **Introduction**

One of the most significant changes in computer technologies in recent years has been the shift away from desktop computers towards more mobile devices and in particular, the emergence of the tablet. Managing this change requires a high level of readiness by both individuals and organizations. Tablet sales have skyrocketed since Apple introduced the iPad in 2010 and now outsell traditional desktops and notebook sales combined and are expected to continue to do so (see table one). Recently M2 Presswire observed that sales of desktop PC's have declined by nearly 20% evidently because, "consumers dedicate more of their budget to other devices like tablets" (2013).

Table 1. Worldwide Device Shipments by Segment (Thousands of Units) Atwal (2014)

Device Type	2013	2014	2015
Traditional PCs (Desk-Based and Notebook)	296,131	276,457	261,005
Ultramobile Premium	21,517	37,608	64,373
PC Market Total	317,648	314,065	325,378
Tablets	207,082	229,085	272,904
Mobile Phones	1,806,964	1,859,946	1,928,169
Other Hybrids/Clamshells	2,706	6,462	8,609
<b>Total</b>	<b>2,334,400</b>	<b>2,409,558</b>	<b>2,535,060</b>

There are signs that the interest in tablets is maturing, which has led some to argue that they are purely a niche consumer device (Reed, 2010). Regardless, tablets are now commonplace and are here to stay. This reflects changes in the way we commonly access information and will continue to change the way we access it with new tablet applications coming out every day. Atwal observes that, "the device market continues to evolve, with the relationship between traditional PCs, different form factor ultramobiles (clamshells, hybrids and tablets) and mobile phones becoming increasingly complex"(2014). The trend towards smaller, more mobile devices with primarily touch screen interfaces has implications for many sectors of the community including educational environments that specialize in teaching information technologies and systems.

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Education is a complex business with a long history of practitioners looking for the latest gadget to improve or change learning. As with any new technology Murray and Olcese (2011) point out that there are the enthusiasts, or early adopters, that insist tablet technology will transform learning and then there are the skeptics who believe that it will make no difference. Technological change happens in Education, but, as Marcovitz observes, it is difficult and takes time. He adds that, “we must focus on the innovation, the people, and the culture of the school” (2006. P.13). The introduction of tablets into learning environments, therefore, is no different from a long list of other technologies introduced over the years; it must be done right.

Many studies exist that examine the use of tablets and their applications in various learning environments (Palmo *Thinley et al*, 2014). Despite the availability of hundreds of thousands of apps, Murray and Olcese in their review of educational software declared, “we do not think the iPad will ignite a revolution in schools” (2011, p. 48). Yet, there are many studies of instances in which tablets can aid learning indicating an evolution rather than a revolution in technology. In the UAE, for instance, Hayhoe demonstrated how well an iPad could be adapted for special needs students using its intuitive navigation and multimedia capabilities. Bennett has demonstrated how just a few tablets in a classroom can have a positive impact on individualized learning with the key being, “innovative instructional design”(2011-12, p.23). A tablet PC, as van Oostveen et al point out, “cannot by itself, instigate redefinition of learning tasks to allow for meaningful learning to occur” (2011, p 78). The learning environment needs to suit the affordances of the tablet.

This study takes a different perspective by physically deconstructing the tablets and using their components in an activity centered LBD environment for teaching hardware courses as well as desktop computer components used previously. The focus is on the hardware rather than the software. Moving from easily available stock components to tiny, bespoke pieces is a large change. Are the students and the organization ready for this change? Do they learn more or less about hardware using tablets? Is it an effective change, an improvement on the old way of doing things?

### **Readiness for Change**

All organizations, including educational institutions, need to keep up to date and change to be relevant in the marketplace. As Edmunds puts it, “They need to react quickly to the global revolution while at a local and national level have to keep up with new technology and competition if they want to stay ahead of the game” (2011, p. 349). With the emergence of tablets globally as personal computing devices, educational institutions therefore, need to examine how they can best incorporate these new devices into learning environments. However, changes such as these naturally create tension or resistance to change within the organization, which can be addressed by examining models of readiness for change.

Stemming originally from Lewin’s (1948) work on unfreezing and freezing behaviors, organizational Readiness for Change (RFC) has been described as a process by Kotter (1995). This process is influenced by key factors which, according to Lehman, Greener and Simpson (2002), include aspects of the individuals involved in the change including their motivation, skills and knowledge as well as aspects of the organization, such as the availability of suitable resources and the organizational climate. Armenakis and Harris (2002) grouped RFC factors into five main categories namely: Discrepancy; Principal Support; Efficacy; Appropriateness; and Valence. Recently, in a study of a Dubai e-government initiative, we suggested that these categories can be viewed from a variety of depths from micro to macro depending upon whether the lens is focused on the individual or on wider organizational issues (Samara and Raven, 2014).

In this study we will use this micro-macro RFC model to examine an instance of technological change in a hardware class. Of interest is how efforts to meet current trends away from desktop PC’s towards more mobile devices in an educational setting are influenced by both individual and organizational RFC factors. The context of the study is at a vocational college in the United Arab Emirates (UAE).

### **Learning by Doing at HCT**

The Higher Colleges of Technology (HCT) is the largest provider of tertiary level education in the UAE with 17 campuses around the country that offer applied bachelor degree programs to Emirati students in a variety of disciplines including Computer Information Science (CIS). As I have discussed previously, the colleges emphasize the applied aspects of learning with a view towards building vocational skills and the emiratization of the workforce in the UAE (Raven, 2011).

Recently HCT adopted the Learning by Doing slogan (LBD) to highlight its support for active learning strategies in all courses and programs of study. Support for activity centered learning is not new, deriving from Confucian ideals and underpinned by constructivist philosophies (Gergen, 1995, von Glaserfeld, 1995). Constructivist approaches to education encourage student- centered, active learning environments that Newman, Griffin, & Cole (1989) once described as a “construction zone”. LBD approaches help avoid the “catatonia” that can occur in passive learning teacher centered environments (Felder and Brent, 2003, p.282). HCT similarly supports active learning strategies stating that LBD, “is an approach to education where students acquire essential knowledge and skills through active, self-reflective engagement with the world inside the classroom and beyond” (2015). Obviously some courses are better suited for LBD than others depending on the subject matter with IT classes typically being good candidates due to their emphasis on building practical skills and knowledge.

As Sakar and Craig point out, a common problem with computer hardware courses is that they can be, “rather dry and theoretical” (2006, p. 150), which can demotivate students. These authors specify that a hands-on, LBD approach should be used to enhance learning in this particular subject. Since their inception approximately 20 years ago, computer hardware courses at HCT have always been lab based, with a requirement that students build computers from components before going on to configure and network them. The stated course learning outcomes (listed below) of the current hardware course, listed as CIS-1103: Hardware and Networking, reflect this practical approach:

- CLO 1- Recognize various types of computer systems: identify and explain the function of their components.
- CLO 2- Construct a computer from physical components and recognize different hardware components and specifications.
- CLO 3- Define the role of operating systems and demonstrate the ability to install and apply the required configuration of an operating system.
- CLO 4- Explain standard network models and demonstrate the ability to construct and operate a peer to peer network.

In the first semester of the 2014-15 academic year it was decided by the system wide CIS academic team that tablet kits should be introduced in CIS-1103, being offered at nine separate campuses, to augment the traditional desktop kits that had been used for many years to meet the second learning outcome. All in one kits were sourced from China. Figure one illustrates the components and an assembled working tablet.

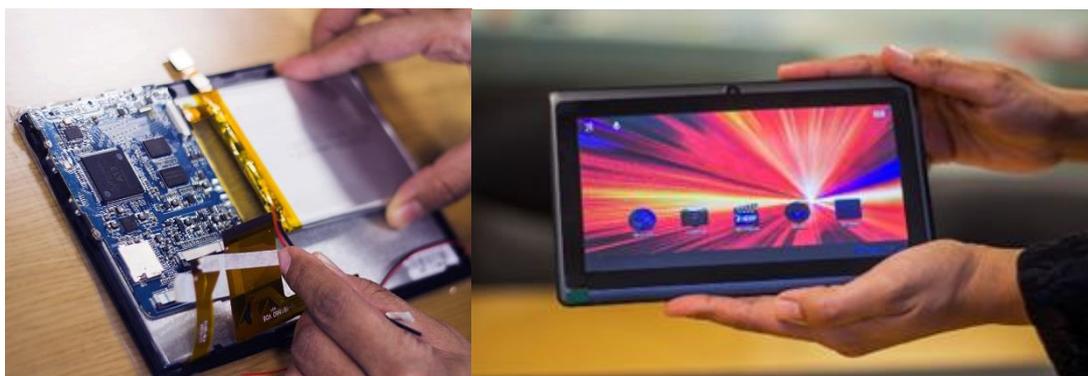


Figure 1. Examples of the tablet PC kits

Unlike desktop PC components that can be used for many semesters, the tablet kits required soldering and can only be used once. To recoup costs, it was planned that the working tablet PCs would be sold off at the end of each semester. To help students, step by step instructions and videos for assembling the tablets were developed and provided to students, as seen on the laptop screen in figure two next to a student soldering wires that connected the individual components together.



Figure 2. A student soldering the tablet components together

Naturally there were concerns about how well teachers and students adapted to the tablets and learned from them with some enthusiasts and some skeptics - as expected. As part of the new initiative faculty at one of the largest campuses, located in Sharjah, decided to carry out research into the effectiveness of these changes being made to the way the course was being taught.

## Method

Two different surveys were given out towards the end of the first semester during the 2014-15 academic year to students and faculty involved in the hardware course. During this semester both traditional desktop PC and tablets PC kits were used as a transition method so that the two platforms could be directly compared. One survey was designed for faculty teaching the course across different campuses and the other to five sections of students taking the course at the two Sharjah campuses. The survey used a mixed method approach containing quantifiable fixed choice questions and qualitative open ended questions. The questions are revealed in the results in the next section. Because the faculty were spread around the UAE and also because of the need for anonymity, the faculty completed the survey electronically (using [surveymonkey.com](http://surveymonkey.com)) while the students filled in written surveys, which was easier as they were all in one area. A total of 11 faculty teaching the course and 82 students taking the course completed surveys.

## Results

The results are divided into two sections. First, the faculty responses or perceptions of change, in chart form with a representative selection of qualitative data followed by the student responses.

### Faculty Perceptions of Change

The first three questions in the faculty survey were designed to assess readiness for change on both the micro, or individual level, and the organizational or macro level. Two other direct questions assessed whether the faculty thought that the change was effective for learning, that is, an improvement.

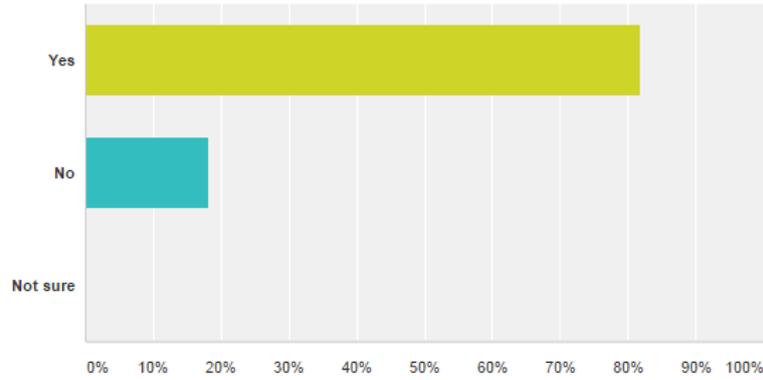


Figure 3. Was it a good idea to switch from building desktops to tablets in this course?

This result shows how supportive the faculty were to the idea of incorporating tablets into the course. They were strongly in favor, which reflects their openness to change.

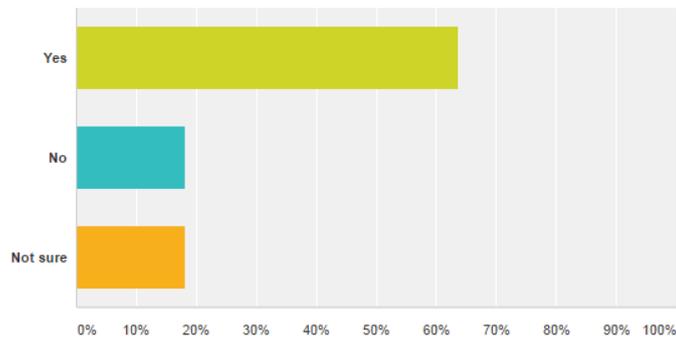


Figure 4. Was the college ready to change from desktop to tablet kits?

This finding indicates that the faculty believed that sufficient resources were provided by the college for changing to the tablet PCs. This indicates a high level of organizational readiness for change at the macro or organizational level.

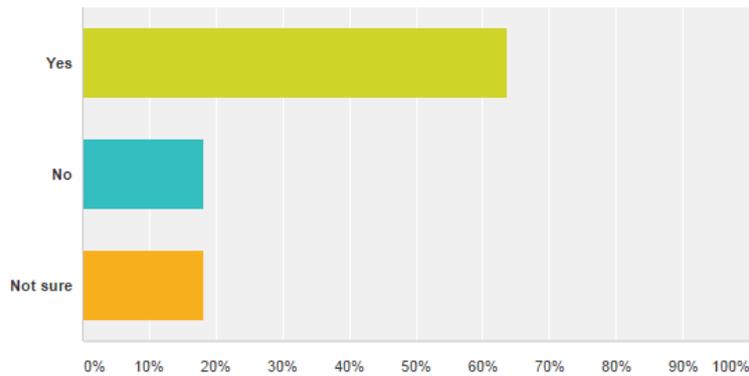


Figure 5. Were faculty provided with enough training and skills for the tablet kits?

Individually the large majority of the faculty responded that they were sufficiently skilled to teach the course using tablet PC kits indicating a high level of individual or micro level readiness for change. This result also supports a high level of organizational readiness for change through the provision of sufficient professional development.

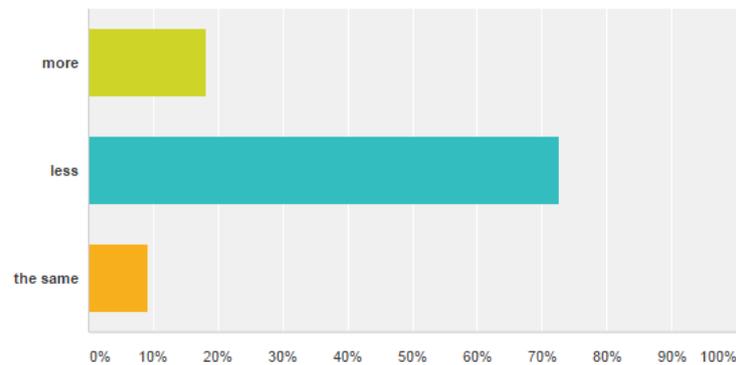


Figure 6. Do you think students learn more or less about basic hardware concepts using tablet kits in comparison to desktop kits?

The large majority of the faculty, while ready for change, thought the students learned less about basic hardware concepts using the tablets. This is surprising given their support for the idea and individual readiness for change.

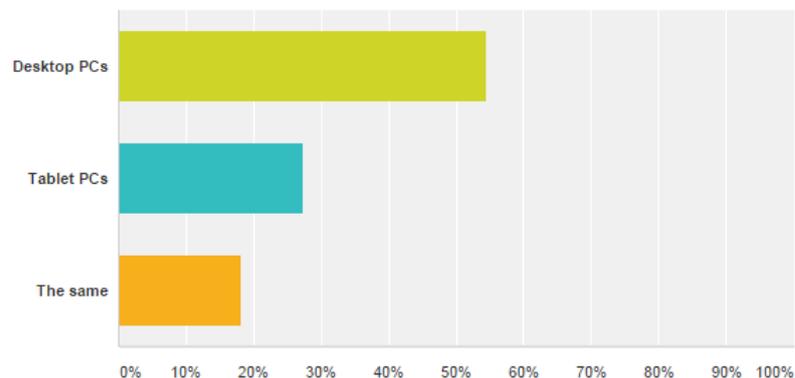


Figure 7. Which do you prefer for teaching hardware concepts?

Adding to the result above, many of the faculty preferred using traditional desktop PCs for teaching basic concepts, although there was also some support for using tablets as well as for both. The qualitative results were designed to give more information regarding these preferences.

### ***What are the Benefits or Advantages of Changing to Tablet Technology?***

The faculty comments listed below endorsed the need to keep up to date with new technologies:

- We should adopt using modern technology.
- New experience for the students. The experience was beneficial as the students are more attached to tablet devices
- The students found it very interesting and challenging. It is a product in the market not like desktops as they are losing the market to All in One computers.
- Its more up to date current technology. Students relate more to this than desktops.
- Students were excited and enjoyed learning wiring & soldering skills in addition to knowing how components are assembled in Tablets

The last comment reflected a new practical skill introduced with the tablet kits: soldering wires.

### ***Describe Any Issues or Disadvantages Associated with Changing to Tablet Kits***

The faculty comments listed below indicate both practical and learning concerns:

- The number of the labs they practice is much less. No spare components if any are faulty. Not every aspect of the course outlines can be covered here.
- Not an option, students need to touch the basics before the in-built components
- We cannot only teach tablet kits assembly. Prior knowledge of desktop kits is required, because concepts can be more clearly explained here.
- Tablets can easily be damaged through wrong wiring or soldering.
- If better quality tablet kits were ordered, the number of working assembled tablets can be increased..

Half of the comments point out a concern with the fragility of the tablet kits used and half a concern that the tablet kits did not fully address the basic hardware knowledge required to meet the course learning outcomes. Overall, the faculty feedback, while indicating a high level of readiness for changing from one platform to another in this course, also expressed doubt that the changes were effective in terms of improving learning outcomes.

**Student Perceptions of Change**

The students were the recipients rather than the instigators of the change process who worked on both desktop and tablet kits during the semester. We therefore took an indirect approach to assessing the change process and included survey questions that asked them to compare the tablet kits to the desktop kits. This addressed how well the course coped with the change from the students’ point of view we believed.

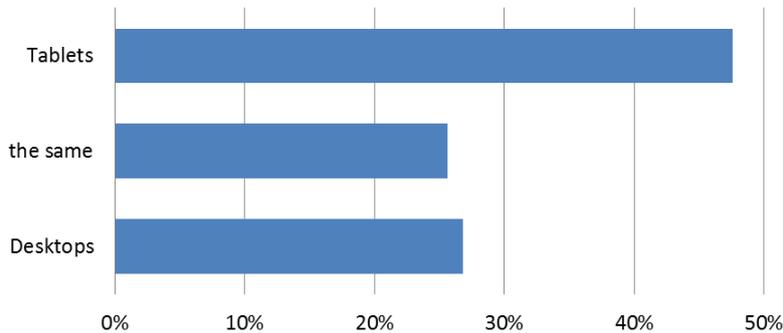


Figure 8. Which was easier to work on – tablets or PC kits?

This result indicates that, in general, the students had no difficulty in changing from building desktop PC kits to tablet kits. Indeed, nearly half, found the tablets easier to work on. This reflects that the course materials and instructions adapted well to the change. This supports the view of a high level of readiness for change for this particular course at both the micro and macro level.

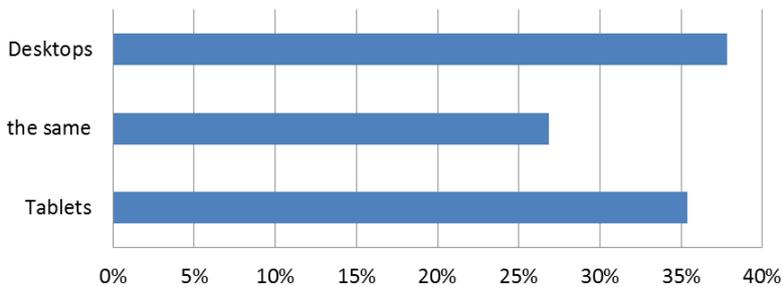


Figure 9. Is it better to learn hardware concepts from desktop PC's or tablet kits?

The mixed response to this question by the students indicates that they had no clear preference, or perception, about the best platform to use for learning hardware concepts which contrasts with the faculty perceptions. The qualitative questions were designed to find out more about their choices. Below is a representative selection of student comments regarding the choices they made regarding a preferred platform.

**Student Written Responses: Why Did You Choose?****Desktops**

- Because we can learn more on the desktops.
- Because desktops have a lots of parts to know and learn what to do.
- Because all hardware parts are bigger and easy to see.
- Tablets are tiny and hard to fix.
- Desktops are much easier to deal with.
- Because we see everything about the computer and know what it is.
- Because it's more difficult than tablets.
- We use desktops more than tablets.

**Tablets**

- Because it has welding.
- It is easier.
- They are simple. Not too many components.
- Because it's more handy and you are able to see everything clearly. Less complicated.
- Easier to use and smaller than the PC.
- Because it is easy to carry it.
- Because the parts of a tablet is easy to learn.
- Its more simple in our level and it's good for starting learning then we can learn more from the desktops in the next level.

**The same**

- Both are important to learn as an IT student
- Because we know it anyway if it is on tablets or desktops.
- Because I can identify every component in both of them.
- Because both of them give us the opportunity to touch the hardware.
- Because we know about any pieces on both and how work together and what the difference in between desktop PC and tablet.
- To know new information.
- Because they are different.
- To take more knowledge
- Actually we will never make tablets and desktops in our lives so it is unnecessary to do it here.

A wide variety of reasons were given by the students for their choices with no clear consensus or preference. Many of the comments about a specific platform concerned practical issues such as the size and number of the components and how they went together rather than how much they learned. Students who chose both the same tended to comment more on learning issues with the majority voicing the importance of both platforms. In terms of assessing readiness for change, the results indicate that the students readily adapted to the tablet kits even though they may not have been aware of broader learning issues that faculty raised.

**Conclusion**

The results indicate that the hardware course was ready for change at both the micro and macro levels even though the use of tablet hardware kits were less effective than desktop kits for meeting the learning outcomes of the course from the faculty point of view. Even though there was willingness to change, the evidence indicates support for retaining both desktop and tablet platforms as LBD activities for various reasons including recognition of the need to keep the course fresh using modern technology while retaining the learning benefits of using traditional desktop hardware. The results from the students indicate their willingness to change also, as many commented that tablets were easier to work on than PC's but were evenly divided about which technology was better for learning hardware concepts. These findings echo Lehman et al's observation that, "Although organizations need to be able to adapt to changing demands and environments, change for change sake does not necessarily lead to more effective outcomes"(2002, p. 198 ). In this course, there is a need and a readiness to keep up with rapid changes in computer hardware yet retain the core concepts of computer systems at the same time using traditional components.

Readiness for change, while useful for understanding the factors that contributed to the acceptance of new technologies in this setting, was not sufficient in itself for supporting effective change. This suggests the need to

view the outcomes, as well as the inputs and processes measured by the micro-macro RFC model, when assessing change in contexts such as this. A possible link between LBD and RFC was illustrated in this study. We believe that the high level of RFC demonstrated at both the micro and macro levels in this context was due, in part, to the use of a student-centered LBD approach. LBD incorporates active rather than passive learning, which by its very nature is dynamic and more ready to embrace the change process. This highlights that change and learning are intrinsically related. We suggest that further research could be conducted into the relationship between the LBD and RFC constructs.

## Recommendations

It is recommended that a readiness for change perspective be taken into account for all courses that are undergoing significant change as well as traditional outcomes evaluation. For the CIS-1103: Hardware and Networking course it is recommended that PC kits be retained as well as the tablet kits as it has been demonstrated that both add value to student learning for different reasons. It is also recommended that this course continue using LBD activities and continue to be ready to change to include new hardware as it becomes available in the market and that the quality of the hardware be optimized as much as possible.

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