

understanding of the IoT concept as it aligned with the definition provided by IBM (2021) and Ndubuaku and Okereafor (2015). Participants described the IoT as a device or a set of devices that connect to the internet via a unique identifier called an Internet Protocol (IP). Participant eight described the IoT:

That's a very broad thing. Ultimately, I suppose I would imagine IoT is the amalgamation of the concept of the information highway and, and what you would typically costs as, as smart devices. Anything that performs a particular function that can possibly either participate in a hub or a hive to achieve a set of objectives. (Participant 8)

One of aims of an IoT device is to enhance the human world(Perera et al., 2013). Participant two highlights the simplification of a user's life in her definition of the IoT below:

IoT helps simplify life by connecting different appliances to each other, and making a human intervention much easier. So, in my understanding, IoT for Internet of Things would be having smart devices, both at home and at work, so that you can control it remotely, as well as get notified remotely. (Participant 2)

Several participants stated that IoT devices share data with other smart devices that assist them in making a decision or fulfilling a task. Participant nine indicated this data collecting and sharing feature and provided an example of an IoT device use case in their below definition:

It's anything as like a connection of different systems or devices that can communicate to each other with its own network, or whether it's in a greater network, like for example, ... Apple did a lot of thing with your

Mac and communicates very well to your iPhone kind of thing ... from your smart speakers, to you for your smart fridges now, I mean, washing machines, dishwashers ... And exchange data in real time, was a very important thing as well, when I think about Internet of Things. (Participant 9)

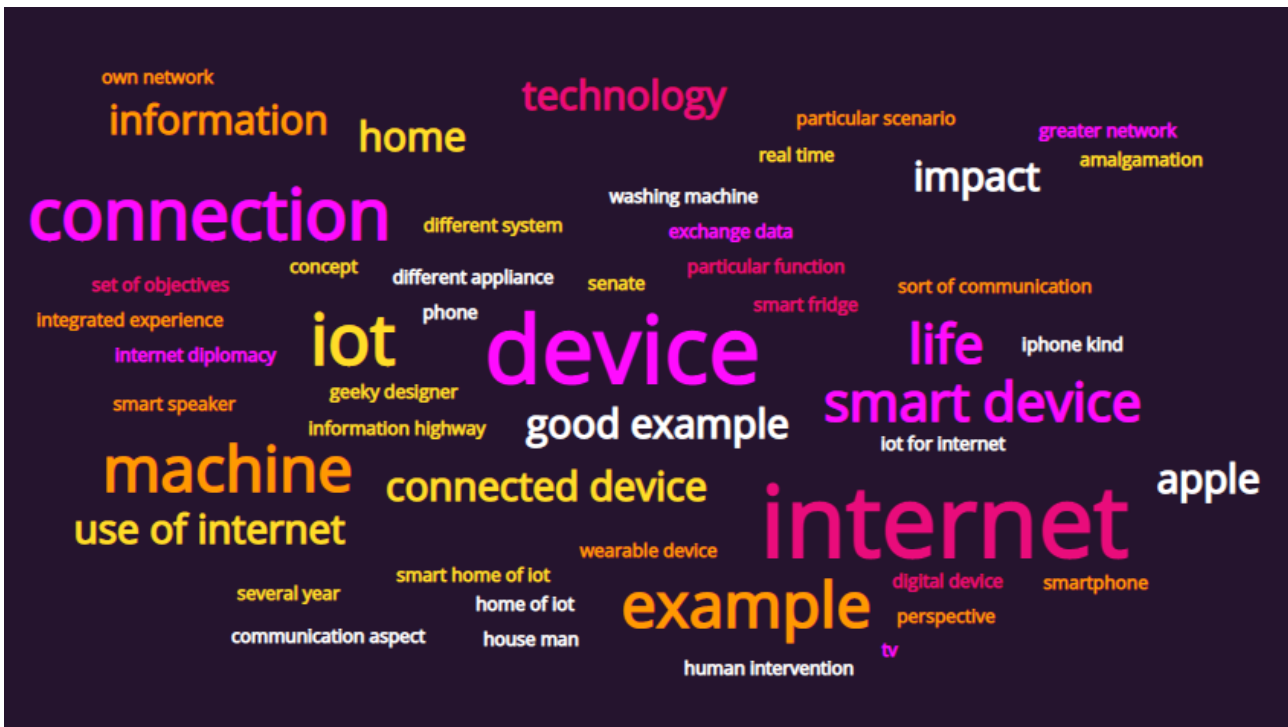
As part of the interview response analysis, three themes were identified: devices that communicate with other devices via local network or the internet, IoT devices that share information with other devices to complete a task or function and simplify users' daily lives. Frequency count was then used to identify the occurrence of each theme in the participant's response. Table 20 provides the summary of identified emerging theme in participants' responses for the definition of the IoT.

Figure 7 highlights the common words that occurred in the participant response. A word cloud generator was used to create the image.

Table 20: IoT Definition Summary (Researcher's Analysis)

Identified Sub Theme	Response Count
Devices that communicate with other devices via the local network or the internet.	10
Devices that share information with other device to complete a task or function	3
Simplifying users' daily life	2

Figure 7: Internet of Things Definition - Word Cloud



The second question under the concept understanding section was:

“What is your understanding of the Human-Computer Interaction (HCI) concept?”

The question focused on collecting data on participants' understanding of the HCI concept. The purpose of asking the question above was to ensure that the participants had a fair understanding of the concept since the upcoming question was linked to it. Based on the analysis of the transcribed interview, all the participants had a basic understanding of the HCI concept and its purpose.

The explanation provided by the participants aligned with the definition provided by Hewett et al. (1992). Participant one provided the following explanation of the HCI concept:

Human computer interaction is the way in which people interact with the computer system, and then computer system[s] being the software[s] that we can provide. And also, the sort of physical devices which can either be a mobile, and how easy it is for a, for a user to be able to use

the products that we give to them either via software product or hardware product. (Participant 1)

Based on the explanation above, Participant one described the Human-Computer Interaction (HCI) concept as the relationship and interaction between the end user and technology. The participant also highlighted the device's ease of use as a focal point of Human-Computer Interaction (HCI).

Participant three highlighted the importance of considering the requisite end-user cognitive load and the mental model while building the device for end users in the concept explanation of Human-Computer Interaction (HCI) below:

In a nutshell, it is the study of how humans interact with computers, you know, and the other way around. So, its human computer interaction is not one dimensional is not just about the human or the user clicking on buttons for the computer to do something. It's all got to do with, you know, cognition as well. Just the study of human psychology, as well as a bit of that, which is kind of like also embroiled in in UI/UX design. There's that lens as well. As you need to understand, you know, mental models and stuff like that. (Participant 3)

30% of the participants also mentioned that the device needs to be built around end users' needs and wants; designers should follow a human-centric approach to building devices.

As part of the interview response analysis for the second question, four themes were identified: HCI defines the relationship and interaction users have with a machine or technology, HCI defines device useability, designing devices in a manner that places users at the centre of the process and the requisite user cognition load to process information or

instructions. Frequency count was then used to identify the occurrence of each theme in the participants' responses.

Table 21 provides a summary of the identified emerging themes in participants' responses on their understanding of the HCI concept. Figure 8 highlights common words that occurred in the participants' responses. A word cloud generator was used to create the image.

Table 21: Human-Computer Interaction (HCI) Concept (Researcher's Analysis)

Identified Sub Theme	Response Count
HCI defines the relationships and interactions that users have with a machine or technology.	9
HCI defines device useability.	3
Designing devices in a manner that puts users in the centre.	3
Requisite user cognition load to process information or instructions.	3

Figure 8: Human–Computer Interaction Concept - Word Cloud



4.3.3 IoT Device Usage and Design Experience

The second section under the semi-structured interview was: IoT device usage and design experience. The section focused on collecting data related to the participants' IoT device usage experiences and IoT device design experience. The purpose of collecting data related to the IoT device usage experiences was to understand the current user experience that the participant had while using a smart device. The purpose of collecting data related to device design was to establish whether the participants had previously been involved in designing a smart device. This information assisted the researcher in understanding participants' design experience with building IoT devices.

The first question under the IoT device usage and experience section that the participants were required to answer was:

“Explain your experience with regards to usage of an IoT device.”

The question focused on collecting data related to the participants' user experiences and providing detail about how satisfied they were with the product. Based on the analysis of the transcribed interviews, six of the participants had positive experiences with the smart device that they were currently using and they mentioned that the device had simplified

their daily lives with the functionalities they offered (based on the device type). Participant two described their experience with a smart home device:

So, my usage of it is very simplified. I do have a smart fridge, dishwasher and washing machine that basically notifies me when there's either an error and I can control it remotely. So, as an example, my fridge I can do like express freezing and all of that and control the temperature of the fridge from my cell phone. For my washing machine, and my dishwasher, it notifies me if there's an error, like rinsing aid to the dishwasher or remove the water from the tumble dryer once it starts drying clothes, it does send me notifications in that sense. But it also makes my life easier because it does notify me when either cycle is finished. (Participant 2)

Participant ten mentioned that the smart devices were an extension of her.

Four participants did not have good experiences with smart devices and raised the following disadvantages: The instructions provided for setting up smart speakers were insufficient and that less computer literate users may not have the necessary knowledge to set up the smart devices on the same network, smart device compatibility with other manufacturers' smart devices and a smart device like Alexa Echo not being configured for South Africa in the product's early stages. Participant five labelled the smart speaker 'bleeding technology' instead of cutting-edge technology, due to them adopting a product that was brand new to the market.

Participant 9 explained their experience with smart home assistant:

Guess the one that I use commonly would be my Google Home assistant and I think it works well. The biggest gap there ... it's using your voice, it does struggle with like, some of our accents or inflections,

if you wanted to play, for example, an Afrikaans, Portuguese song kind of thing. ... Because the artist's name is not in that American Google Voice. So, it does break in there,... I think Google's done good at allowing it to discover other devices. So, for example, like my Chromecast, my IP camera, for example, when I have my Chromecast on my TV, so these things can communicate to each other. And it kind of enriches their environment ... And I think now, as I've kind of progressed on this journey, you know, when I look for like a new smart device, I actually check to see if it's compatible with my Google Home assistant, because I don't want to not get another interface, just interface to that. I do see that as gaps in the market. (Participant 9)

From the experience above, the participant indeed had a good experience but the device struggled to fulfil all the tasks due to the language barrier inherent to the device. The participant also had to keep the device compatibility element continuously in mind when purchasing a new smart device, owing to different interfaces required by different manufactures.

Four themes were identified from the interview responses analysis of the first question: A great experience with no issues and it simplified the participant's life, available functionality on the smart device enhanced user experience, not the best experience as the participant struggled with setting up and using the smart device and over time, the participant learnt how to operate the smart device. Frequency count was then used to identify the occurrence of each theme in the participants' responses.

Table 22 provides a summary of the identified emerging themes in participants' responses for IoT device usage experiences. Figure 9 highlights common words that occurred in the participants' responses. The researcher used a word cloud generator to create the image.

Table 22: IoT Device Usage Experience (Researcher's Analysis)

Six out of ten participants had IoT device design experience. These participants have been involved in different stages of design based on their skill sets and expertise. Participant four described their IoT device design experience:

One that I've been involved in ... It's a device that gets added to a gun. So, it's in the security industry. And then that gun it basically takes video and it can count how many shots is fired. So that little device is connected on a physical device on your, on the pistol, the gun. And then based on movement, you know, obviously streams the video ... You know, based on the movement in count the number of shots that was fired and so on. So that if there's security and policing, so that if there's an incident, people know ... those immediately what's happening. (Participant 4)

Participants had been involved in various industries which includes security, household, banking and automotive. Participants worked on the following use cases: IoT device data processing use cases for a smart tracking device that are installed on a vehicle, monitoring a dashboard for smart devices used within a banking industry, smart sensors installed on guns and vehicles, and mobile apps that assist end users to control their smart home. Participant eight provided consulting services on the IoT device data use case and describe the design experience:

In terms of some of the data processing, use cases that were there, that is in relation to a chip-based system that monitors you'll get the chips that you install on cars, and vehicles for monitoring certain parameters on the vehicles in terms of consumption, driving style, that kind of thing. (Participant 8)

4.3.4 IoT Device Design Elements

The third section identified through the semi-structured interviews was IoT device design elements. This section focused on collecting data related to the design factors that should be considered when building a smart device. Participants were required to answer two questions related to IoT device design. The purpose of the section was to identify which factors were currently considered by skilled experts while designing a smart device for end users and their thoughts on incorporating the HCI component in the design stages of a smart device.

The first question under the IoT device design elements section that the participants were required to answer was:

“What are your thoughts on incorporating the human computer interaction component while designing an IoT device?”

The purpose of collecting the data above was to understand if the participants were considering the HCI component when building the device for end users and what their thoughts are on adding the component to the design phase.

Based on the interview transcription analysis, seven participants highlighted that it is an important factor to consider when building smart devices. Participant three highlighted the need to focus on the HCI factor in the device build stage as well building the device around the end user:

I think there has been a lot of studies and a lot of research done, you know, a lot of experiments, etc. And I think, like, the IoT space, like, its higher quality, it's technical by nature ... Led by, you know, techies ... But most developers are mainly concerned with like, code. And the way that they write code, forgetting that whatever that they developing, is going to be used by people in humans. So, you need to, you know, place the human at the centre, ... So, I think there needs to be like, heavy involvement, you know, from a UX perspective, or from a product design, perspective, and an ethnography, prospective research, as well,

that's also that, yeah, that's also the key component ... But again, what's the point of all that powerful technology, people are not going to be able to use it? (Participant 3)

From the participant's response, the importance of considering the human factor when building a smart device is noted and explained.

Participants also discussed the device useability factor as well as that the device must be built in a manner that seamlessly integrates with an end user's current lifestyle. Participant ten explains the seamless component in the following statement:

I think it's super important because you don't want somebody to have to learn a new thing. I know that technology's you know, generally branded as disruptive, but I don't think technology should disrupt your life, I think it should plug in to what you're doing your normal, ... it should just be like an extension of you a continuation of you, which you shouldn't have to stop and learn a new thing and stop and figure something out ... So if you're going to have that component baked into IoT, then I think it's going to work brilliantly, because IoT devices usually live in your home. And that's a personal space. (Participant 10)

Three themes were identified from the interview response analysis of the first question; an important element to consider when building an IoT device for end users, following a user-centred approach when designing the IoT devices and designing devices that are useable for all types of users (computer literate users or users who are not computer literate). Frequency count was then used to identify the occurrence of each theme in the participants' responses.

Table 23 provides a summary of the identified emerging themes in participants' responses to thoughts on considering the HCI component. Figure 10 highlights common words that

Participants have different sets of elements that they would consider when designing a device but an important element mentioned was that the device should be easy to use by an end user. Participant four elaborated on the importance of device useability and configuration in the following statement:

That the interface that the user use must be very simple. And it must be configurable ... you should be able to ... clap your hands twice to switch on the lights and want[s] to switch it off, but somebody else might want to say you know, lights on lights off, you know, voice activated so that's what I mean by configuration ... when you get to more sort of high-end users or technical inclined users, they would want to configure it.

(Participant 4)

Participants also mentioned the physical device build elements that should be considered when designing a device, the device usage data presentation and the type of use case that they are building for. Participant seven explains the elements that need to be considered when designing an IoT device:

You want to ensure that the information that's been given back to the user is in a presentable manner, so that it's easy to understand ... the language is available for the person to understand the units of measure relevant to that particular country ... the actual physical device ... probably waterproof, and it can withstand the weather. It's not a hazard to animals, it's on a farm. I guess it depends on a very specific use case scenario, that the fact is you'd need to consider you'd have obviously functional and non-functional requirements for that particular device.

(Participant 7)

The importance of catering for all types of users was highlighted by Participant ten in the following statement:

A big thing for me would be for these devices or platforms, to accommodate people of all literacy levels ... it should be so easy to pick up and so intuitive that I should be able to use it as well as my grandpa should be able to ... different people have different needs for technology ... technology plug into your life in such a way that it meets your specific need. (Participant 10)

The following themes were identified from the interview response analysis for the second question:

1. Device Useability – This theme focused on ensuring that the smart device is simple enough for the end user to operate. This theme can be linked back to Norman’s design principle called: ‘*Signifier*’, which guides the end user on how to utilise the object (D. A. Norman, 1998).
2. Device Configuration – This theme focused on ensuring that the device is designed in such a manner that an end user can easily configure and control the smart device. This theme can be linked back to Ben Shneiderman golden rule called: ‘*Support internal locus of control*’, which allows the user to easy control and manage the device(Shneiderman, 2004).
3. Device Interoperability – This theme focused on ensuring that the device can seamlessly integrate with different device manufacturers. This theme can be linked back to the research finding by Rowland et al. (2015), where an important design element to consider is interuseability. This element requires the user interface to be similar across different set of connected devices.
4. Cater for all literacy levels – This theme focused on ensuring that the device can cater for end users who might not have much technical knowledge. In sum, catering for all types of end users.
5. Identifying the use case for the smart device – This theme focused on identifying the existing problem and type of end user they are trying to solve the problem for. Understanding the use case is imperative for smart device build. This theme can be

linked back to research conducted by Woo & Lim (2015), where do-it-yourself (D.I.Y) smart home products were designed to solve existing issues faced in an end user's daily lives.

6. Understanding and meeting end user need. This theme can be linked back to the Quality of Experience (QoE) metric, which ensures that device design meet end users requirements (Fiedler et al., 2010).
7. User interaction method – This theme focused on different types of interaction methods which can be used by end users to interact with the smart device. This theme can be linked back to the research findings by Nazari Shirehjini & Semsar (2017), where it was highlighted that it is prominent to identify the type of interaction that will be used to interact with IoT devices.
8. Physical device build – This theme focused on the device hardware element and environment condition that needs to be considered. This theme can be linked back to the research finding by Perera et al. (2013), where IoT devices hardware requirements were discussed. As stated by Woo & Lim (2015), an IoT device integration should not disrupt existing home interior.
9. Environmental impact – This theme focused on the smart device usage impact on the environment. This theme can be linked back to research finding by Jensen et al. (2018), where smart home devices should assist in reducing energy consumption.

Table 24 provides a summary of the identified emerging theme within the participants' responses to the elements that need to be considered when building an IoT device. Frequency count was then used to identify the occurrence of each theme in the participants' response. Figure 11 displays the common words that occurred in the participants' responses. A word cloud generator was used to create the image.

Table 24: IoT Design Elements (Researcher's Analysis)

Theme	Count
Device useability	3
Device configuration	2
Device interoperability	3
Cater for all literacy levels	3
Identify the user case of the smart device	3
Understanding and meeting end user need	3
User-Interaction Method	3

Physical device build	2
Environmental impact	2

Figure 11: IoT Design Component - Word Cloud



4.3.5 Data Collection and Presentation

Data collection and presentation is the fourth section identified under the semi-structured interviews. This section focuses on collecting data related to the participants' thoughts on device usage data collection and the presentation of the usage data to the end users. Smart devices require data to fully operate, indeed, Ndubuaku and Okereafor (2015) state that data is like fuel for smart devices. Participants were requested to answer two questions related to data collection and presentation.

The first question under the data collection and presentation section that the participants were required to answer was:

“What are your thoughts on the IoT data collection from end users?” The purpose of collecting the data above was to understand and identify the components that are considered when collecting and processing device usage data. Participants were requested to explain how they felt about the data collection process and the measures that could be implemented to enhance the existing processes.

Five Participants mentioned that data collection is imperative for enhancing user experience of the smart device. Participant ten explains the benefits of data collection in the following statement:

I have two minds about it ... if it [is] for the purpose of improving my experience, because again, I think these devices can only serve you better according to how much they know about you, right? When you plug in for the first time, your experience will be different from when you're 100 days in, because this is you're feeding it information about yourself, so they could just know you better. (Participant 10)

While data collection is imperative for device functionality, a number of participants also highlighted the issue of data privacy, transparency and the types of data collected from the end user. Participant three addressed the data privacy and transparency issue:

You know, privacy is a huge thing, confidentiality, those are huge things when it comes to data collection ... transparency as well, is a problem, because if I'm using tell me that I'm collecting your data, or can I please collect the data? ... Then I'll be able to assist and say, okay, my data is going to be used for this, I'm uncomfortable with it or not, if I'm comfortable, then yes, if I'm not, then, you know, I don't consent as simple as that. So, the transparency for me is a huge issue and the fact that we even have talked about this in itself. (Participant 3)

Educating end users about what the collected data will be used for is crucial. Smart devices placed in a personal home setting might be collecting data that is confidential and sensitive for the end user. Participant nine noted the lack of education in the following statement:

I don't think people understand what they're signing up for or giving away. I think a lot of people just accept it ... I see Google, for example, is doing a lot of steps to try explain those to customers ... and I don't really typically see that in like an IoT device, you know, when suddenly would ask for other information. And I think there needs to be better ways of communicating that to customers. (Participant 9)

Six themes were identified from the interview response analysis for the first question: Data collection required by device manufacturers to enhance user experience, data privacy, i.e., the confidentiality and sensitivity of the collected data; complete transparency required in data collection and usage; effectively educating end users about what the device usage data will be used for; end user comfort level is dependent on the type of data collected and what it is being used for; and data security, i.e., the storage, access and transfer of data. Frequency count was then used to identify the occurrence of each theme in the participants' responses. Table 25 provides a summary of the emerging themes identified from participants' responses to the thoughts on the IoT data collection component. Figure 12 displays the words that frequently appear in the participants' responses. A word cloud generator was used to create the image.

Table 25: IoT Data Collection (Researcher's Analysis)

Theme	Count
Data collection required by device manufacturers to enhance user experience.	5
Data privacy: Confidentiality and sensitivity of the collected data.	5
Complete transparency required in data collection and usage.	4
Effectively educating end users about what the device usage data will be used for.	3
End user comfort level is dependent on the type of data collected and what it is being used for.	3
Data security: storage, access and transfer of data.	3

giving you insights that helps you benefit and significant changes, things that you would not have noticed before. (Participant 7)

Participant nine mentioned that an IoT data collection report could be provided to the end user monthly, to display what types of data are being collected and instructions on how to prevent data from being collected if the end user is not comfortable with it.

The importance of selecting the best visualisation method was also mentioned by three participants because the wrong interpretation of the visualised data could lead to confusion and end users feeling overwhelmed. Participant eight highlights the importance of selecting the correct visualisation in the following statement:

I think is a necessary aspect of that, I think there needs to be considerable talk given in terms of that presentation. Especially if you're presenting information that is very easily misinterpreted and cause users to, it can have consequences. (Participant 8)

Participant three also mentions the factor of knowing your audience and the selection of the correct visualisation method that caters for all types of users in the following statement:

Things that would need to be considered are choosing the right type of visualisation, for the data that you would like to do to display ... telling a story through that data, you know, making it tangible, making it relatable to the person that you're, you're showing it to ... data visualisations tend to be a bit complex. And users generally have to connect the dots, about visualisations ... when it comes to dashboards, sometimes like, if you're not a data analyst ... a dashboard is overwhelming ... basically

knowing your user and knowing your audience for this type of stuff.

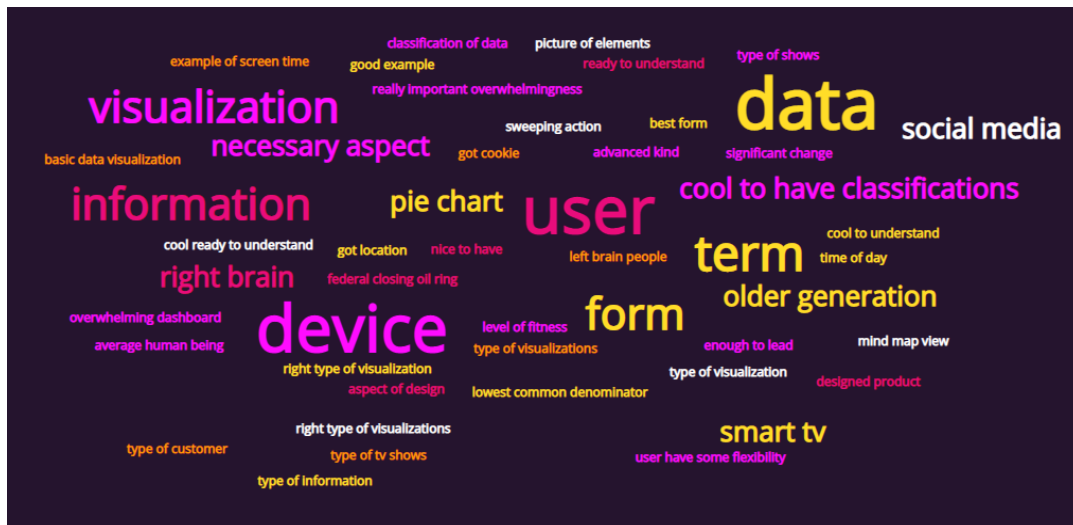
(Participant 3)

Five themes were identified from the analysis of the interview responses to the second question: presenting information and recommendation that educate users on the device usage, knowing your audience, providing valuable insight that assists in decision-making, selecting the right visualisation method that cater for all types of users and understanding what types of information are crucial to the end user. Frequency count was then used to identify the occurrence of each theme in the participants' responses. Table 26 provides a summary of the emerging themes identified from participants' responses to IoT data presentation. Figure 13 features the words that frequently occurred in the participants' responses. A word cloud generator was used to create the image.

Table 26: IoT Data Presentation (Researcher's Analysis)

Theme	Count
Presenting information and recommendation that educate users on device usage.	5
Knowing your audience. Example from the interview: <i>"I think it also depends on the type of customer. Like I said, most guys are just interested in user kind of stuff. It'd be cool if your IoT devices sent you like a monthly report that said, Hey, this is the stuff we collected from you..."</i>	3
Providing valuable insight that assists in decision-making.	3
Selecting the right visualisation method that caters for all types of users.	3
Understanding what types of information are crucial to the end user. Example from the interview: <i>"But I think I would like for the device to sort of draw some intelligence out of it, you know, give me a bit of Intel behind it. If my medical aid is linked to how many steps I take a day, I think my smartwatch should be able to tell me somehow that you know, or discovery or whatever should be able to tell me that doing 10,000 steps a day, for three months will reduce your medical aid claims by this much."</i>	2

Figure 13: IoT Data Presentation - Word Cloud



4.3.6 IoT Device Security

The last section identified through the semi-structured interviews was device security. This section focused on collecting data pertaining to the data security of smart device data. Participants were requested to provide their thoughts on what security elements could be implemented to enhance the user experience pertaining to the security of the device. The data above also assisted the researcher in understanding the participants' thoughts on the security element and what measures were currently being installed to protect the end user data and identity. The participants were requested to answer the following question: “*What are your thoughts related to the security and the data collection element?*”

Five participants mentioned that security is an important element when designing the IoT devices because they are connected to the internet and are vulnerable to external threats. Participant three highlights an end user's comfort level with sharing data with companies in the following statement:

And I guess that's what also make[s] users a bit apprehensive about sharing their data, especially with certain companies. Like security and has been transparent generally ... Is this data that could compromise

my wellbeing or is this data that does not have that much relevance in my life, I guess that's also another thing users would always people open to sharing the data, if they felt that it was safe. (Participant 3)

While device manufacturers require usage data for the device to fully reach its potential and function as expected, participants noted that manufacturers need to focus on capturing data that is essential and prevent gathering unnecessary data. Participant four explains the data collection process in the following statement:

If you use my data, so they tell you, the company and under the user and using my data ... I don't have a problem with you using my data but use it for me. And, and when you use it for somebody else, then make sure that it doesn't directly relate back to me. So, make sure that it's depersonalised ... they need to be concerned that you are collecting this data and that you're processing the data and making sure that you're using it to deliver a service to me and not just collecting unnecessary information. (Participant 4)

An end user's comfort level with device usage depends on how secure and protected the device is. Participant ten explains the existing trust issue with data collecting in the following statement:

I have got a, like a blank, online profile that, you know, has no data about me ... So I'll log into those apps, especially ones that have sensitive information, information with credentials that don't reveal anything about me ... enjoy the content in such a way that the algorithm doesn't build a persona for me and even if it does, it, can't attach it or link it back to me because I want the private things and the sensitive

things about me to remain that way. And it's because of that trust issue.

(Participant 10)

Six themes were identified from the analysis of the interview responses to the first question: An important element to consider when designing the device, the level of security controls (e.g., encryption) that needs to be implemented depends on the data sensitivity, end users will not be fully comfortable with using the device if the device is not secured, collected data should not disclose users' personal identities and location, users' concern level with sharing data depend on what type of data is collected, manufacturers should abstain from collecting data that they do not require and limiting access to the collected data at rest. Frequency count was then used to identify the occurrence of each theme in the participants' responses.

Table 27 provides a summary of the emerging themes identified from the participants' responses on IoT device security. Figure 14 highlights common words that occurred in the participants' responses. A word cloud generator was used to create the image.

Table 27: IoT Device Security (Researcher's Analysis)

Theme	Count
An important element to consider when designing the device. Example from interview: <i>"As a designer, make sure that your device, smartphone, or Smart TV is secured in such a way that you would not be exposing your users to any danger, whether they're on the internet or they're even offline. So I think security is one of the most important thing that we have to do, especially when it comes to protecting the users data"</i>	5
The level of security controls (e.g., encryption) that need to be implemented depends on the data sensitivity.	4
End users will not be fully comfortable with using the device if the device is not secured. Example from interview: <i>"If I was a user, I would definitely use a system that I'm quite confident that it's protected, that I know that my data will not be shared with any other person or there will not be a possibility of a hacker coming in, collect the data unlawfully and going use it somewhere else"</i>	3
Collected data should not disclose users' personal identities and location.	4
Users' concern levels with sharing data depend on what type of data is collected.	4
Manufacturers should abstain from collecting data that they do not require.	2
Limiting access to the collected data at rest.	3

Figure 14: IoT Device Security - Word Cloud



4.4 CONCLUSION

The preceding section provided an in-depth analysis of the semi-structured interview transcriptions. The semi-structured interview structure was divided into the following six sections: participants' demographic data, concept understanding, IoT device usage and design experience, data collection and presentation and, IoT device security. The participants were required to answer a total of nine questions as part of the interview. Based on the participants' responses, most of them had a fair understanding of the IoT and HCI concepts. Several participants noted that they had had a pleasant experience using IoT devices but there were few of the participants who noted that setting up the device was a struggle. Over time, participants learnt how to operate their IoT devices.

Most of the participants also agreed that Human–Computer Interaction is an important element to consider when designing an IoT device. Much of the focus was on catering for all literacy levels and ensuring that the useability requirements are met. The participants mentioned several design components which should be included when designing an IoT

device. For the data collection element, participants asserted that the collected data should mainly be used to enhance their user experience. Data privacy and sensitivity were also noted by the participants. For the data presentation element, participants highlighted that the presented information and recommendations should educate users on their current device usage behaviour. Participants noted that device security is a crucial element which needs to be accounted for when designing an IoT device.

CHAPTER 5: CONTRIBUTION AND CONCLUSION

5.1 INTRODUCTION

The purpose of this research study was to identify the principles of HCI components in IoT devices. Participants who reside in South Africa were requested to complete a questionnaire that focused on understanding the current user experience of smart home devices. To further comprehend the inclusion of HCI components in the IoT design process, case study organisation employees were requested to participate in a semi-structured interview. The following research questions were answered as part of the study: What is the user motivation for purchasing an IoT device? What are users' concerns regarding data collection and privacy? How does information related to IoT device usage is being represented/returned to the end user? What are the challenges of IoT devices in relation to Human-Computer Interaction (HCI)? What components are considered for designing an IoT device?

In this section, the researcher will provide detailed insight that was derived from the collected data and past literature as well as a summary of the findings. This section also focused on describing the incorporation of the activity and cognitive load theory with the research findings. The study's limitations, contributions and future research requirements will be discussed in the concluding remarks.

5.2 SUMMARY OF FINDINGS

5.2.1 IoT Device Purchase Motivation

The South African IoT market has been predicted to grow at a 20.96% rate annually from 2020 to 2025 (IndustryARC, 2021). Smart homeowners are predicted to reach a total of three million users by the end of 2026 (Statista, 2022). To ensure the successful adoption of IoT devices, the device designer needs to consider the end user's wants and needs when building the devices. The purpose of the smart device is to enhance the quality of life (Marikyan et al., 2019) or solve an existing problem being faced by the end user. It is imperative to identify the most common reason that end users consider when purchasing a

smart device instead of a traditional device. Understanding user motivation for using a system is crucial as it has a direct impact on the user experience (Beale & Peter, 2008).

In this research study, the researcher utilised the questionnaire method to identify the smart device details that are used in a household as well as the motivation for purchasing these devices. Past literature also assisted with identifying the adoption of smart devices. These adoption motivations include efficient energy management, financial savings, improved quality of life and improved healthcare within a home (Li et al., 2021). In research conducted by Schill et al. (2019), end users indeed indicated that smart home solutions are environmentally friendly.

This research study focused on smart home device consumers who reside in South Africa. Fifty-seven smart home device end users were requested to provide user experience data about smart home devices. From the collected data, the following information was derived: the most common type of smart home device used within the household environment was a smart television (TV) (68.42%). The second most common smart home device purchased by consumers was smart lights (8.77%). While various types of smart home devices are available on the market, Participants of a household are mostly interested in automating the entertainment objects within their households. Around 42.11% of the participants have had their smart devices for 0–2 years. While smart home devices have been available to consumers since the early 2000s (Taylor & Harper, 2003), the collected data revealed that the adoption of smart home devices by smart home consumers had only recently started since most of the participants have had their smart home devices for less than five years (82.77%).

Samsung (40.35%) was identified as the most common brand of smart home device. The ability to stream entertainment services like Netflix or YouTube (23%) was identified as the most common purchase reason by the end users. The other common reason for purchasing a device that smart home device users provided was an internet connection feature, the convenience features of the smart device, end users required a device upgrade and for the smart feature that included the device being connected wirelessly, device usage monitoring function, etc.

5.2.2 IoT Device Usage and Maintenance Experience

Understanding the user experience concerning smart device usage and maintenance is imperative for device designers to further understand the current challenges faced by end users. To address the sub-problem, the questionnaire and semi-structured interview participants were requested to provide detail on their current usage and maintenance experience with their devices. The slow rate of smart home ownership was highlighted in an article written by a South African digital news provider. Despite the prediction of growth in the smart home market, usage and implementation of IoT devices by consumers in South Africa are 23% less than for global consumers. The following issues were highlighted in the article: unreliable internet or consumer not having access to the internet, the trust in smart devices and the costs associated with automating a household (CBI Electric: low voltage, 2022).

For the questionnaire, fifty-seven participants were requested to provide their usage and maintenance details and for the interview, ten participants were requested to provide details on IoT device usage. The researcher reviewed the collected data and past literature to answer the question. The questionnaire included open- and closed-ended questions that were designed using the Likert scale.

The following information was derived from the collected data on the smart device usage experience and maintenance:

- Almost all participants (98.24%) found the initial setting up of smart home devices easy.
- Most of the participants (82.45%) agreed that the smart device that they had purchased met their expectations and needs. Around 15.79% of the participants were neutral about their expectations being met by the device.
- Almost all of the participants (94.74%) found the smart home device easy to use and maintain.
- While around 35% of the participants did not mention any challenges when using their smart home device, the rest of the participants had faced a number of challenges (65%). The participants highlighted these challenges as being device software upgrades, difficulties in navigating all the features on the smart device,

internet connectivity issues and that the initial setting up required coding and configuration skills. Despite the participants declaring that the initial set up of their smart home devices was easy in the first statement, a number of participants indeed struggled with setting up their smart home devices.

- The most common tool used by the participants to manage their smart devices was the smart device itself (54.39%). The second common type was a mobile application (31%). In a past study conducted by Koskela and Väänänen-Vainio-Mattila (2004), participants were interested in controlling and managing their smart home devices from a central place (e.g., mobile phones or personal computers). This study's results, therefore, align with previous studies.

During the semi-structured interviews, more than half of the participants (60%) revealed that they have had great experiences with no issues when using IoT devices. Some participants (30%) struggled with the initial set up but learnt how to operate the smart device over time. From the above information, it can be concluded that while the participants did find it easy to navigate and use the smart home devices, participants pointed out that there were challenges with a smart home device is placed inside a home. Setting up the device was specified as a challenge in both the questionnaire and semi-structured interviews. The first impression of using a product is crucial and IoT device designers must focus on simplifying the initial set-up of devices for all types of users.

5.2.3 IoT Device Design Components

When building IoT devices for end users to utilise, both technical and non-technical factors should be considered (Vermesan & Bacquet, 2017). The HCI component in the IoT device design-build phase focuses on ensuring that the device is easy to use by the end user and meets their expectations. In a study conducted by Beale and Peter, (2008), it was noted that designers must incorporate emotion into their systems and products. Human emotions are dependent on their interaction with and the functionality of the final product.

To answer the research question, ten organisational employees were requested to provide their thoughts on incorporating HCI in IoT device design-build and what elements are

important when building an IoT device. At the beginning of the interview, the researcher requested participants to provide their understanding of the HCI and IoT concepts.

All participants had a fair understanding of the IoT and HCI components. Around 60% of the participants had previous experience in designing IoT physical devices or the software used to manage the device while the remaining 40% of the participants have worked on integration technical solutions and working with a new set of technologies. From reviewing past literature and the participants' responses, the following information was derived from the researcher:

- Past literature has highlighted the integration of the Norman design concept while building smart devices and the importance of designing a product around user needs and interests (Urquhart & Rodden, 2017). Interuseability between different smart devices also needs to be considered by the design team (Rowland et al., 2015). Most of the participants (70%) consider HCI an important element that needs to be considered when designing IoT devices. The designer should take a user-centric design approach while building these devices since the end user will be responsible for maintaining and operating the device. The smart devices should be designed in a manner that caters to technical and non-technical end users. The research findings align with what has been noted in the past literature.
- Based on the participants' responses, the following factors need to be considered when building an IoT device: the device must be able to integrate and function with other smart devices, the device is easy to use and seamlessly integrate with a household, the device can be used by users with varying literacy levels, an efficient user interaction method must be identified, the physical building of the device, the impact that the device will have on the environment and addressing end-user needs and wants. It is imperative to ensure that the smart device is either addressing a current problem faced by the end user or enhancing their quality of life.

5.2.4 IoT Device Data Collection and Presentation

The data collection process is an important and required function within an IoT device. For the device to fully reach its potential and operate, data is required by the device to build

context and enhance user experience (Ndubuaku & Okerefor, 2015). As part of the semi-structured interview, the organisational employees were required to provide their thoughts on the IoT data collection element. Half of the participants (50%) agreed that device manufacturers require data to enhance user experience. Data privacy and the sensitivity of the data need to be identified and considered when collecting the data as the participants expressed that their (end-user) comfort level depends on what type of data is being collected. Educating end users about the data collection process is an important factor that needs to be provided for when communicating with end users. One of the participants suggested using blockchain technology for data transparency. Device manufacturers need to be fully transparent about what type data of is being collected and what it will be used for.

The importance of data flow visibility and usage transparency has previously been discussed in an article by Schraefel et al. (2017). As part of the questionnaire, fifty-seven participants were required to provide their experiences with smart device data collection, its presentation and how they could access the data. The statement was designed using the Likert scale. The following information was derived from analysing the collected data:

- More than 80% of the participants were aware that the smart home device is collecting data. Around 14% were unaware that the device was collecting data. The participants who were unaware of the data collection element had smart televisions (TVs), smart lights and air fryers installed in their homes. Most of these participants had the smart home device for less than three years.
- Less than 50% of the participants had access to their smart device's usage data and 33.33% of the participants did not have access to viewing device usage data. The majority of the participants who did not have access to device usage data owned smart televisions (TVs), smart air fryers and smart lights.
- The most common tool that is being used to view the usage data detail was the smart device itself (29.82%) and the second common tool used by the end users was a mobile application (24.56%).
- Around 41.11% of the participants were neutral about the presented device data being useful and easy to comprehend. A number of the participants (17.55%) disagreed that the collected data was useful and easy to comprehend.

From the above information it can be noted that there are smart device end users who aren't knowledgeable about data collection processes and access to the collected data. For end users to benefit from the collected data, they need to have access to it and the data needs to be presented in a format that is easy to comprehend by all types of users. Previous research has highlighted the usefulness of a selected visualisation method (Tory & Moller, 2004) as well as of converting raw data into meaningful information that is easy for people to understand (Nuamah & Seong, 2017). Semantic computing can be utilised by IoT device designers to generate meaning from the collected IoT device data, it can also assist with resolving the heterogeneity issue (Sheu, 2008; Sheth, 2016).

The semi-structured interview participants were also requested to provide a list of elements that they consider when displaying collected usage data back to end the user. The requirement to present information in a manner that assists with educating the end-user on device usage and decision-making was highlighted. It is crucial to identify the audience of the visualisation as well as to choose the most effective visualisation type that would cater to all types of users.

5.2.5 IoT Device Security and Privacy Concerns

An IoT device is required to be connected to a network to constantly collect and share data with other smart devices for it to operate within an environment. As the devices are exposed on the internet, it creates potential threats of cyber and denial of service attacks (Singh & Singh, 2015). While the implementation of IoT devices has improved and automated daily tasks in end users' lives, it has also increased security and privacy challenges. Device manufacturers are required to implement the appropriate measures to address security and privacy challenges (Tawalbeh et al., 2020). During the semi-structured interviews, participants were requested to provide their thoughts on IoT device privacy. The security element was highlighted as an important factor by the participants and the following measures were recommended to enhance device security: the collected usage data should not disclose end users' identities or exact locations, the level of security controls that needs to be implemented on the usage data depends on the data sensitivity, the access to data at rest should be effectively managed and limited to required personnel only and device manufacturers should abstain from collecting unnecessary data. End

users' comfort levels with data collection is based on what type of data is being collected. For an end user to fully trust the smart device, it needs to be secured (Coughlan et al., 2012).

In research conducted by Psychoula et al. (2018), end-user privacy concerns for IoT devices were discussed. End users highlighted that they were concerned with who had access to collected data, smart devices not operating as expected and the devices being hacked by cyber hackers. Participants were required to provide their thoughts on IoT device security in the questionnaire. More than 50% of the participants did not have security concerns related to smart home device usage. The majority of the participants who did not have security concerns purchased smart home devices from popular brands like Samsung, Google, LG, Apple, etc. The findings link back to research conducted by Zheng et al. (2018) in which the participants trusted the device manufacturer concerning the privacy aspect. Around 22% agreed that they did have security concerns related to smart home device usage. The participants raised the following concerns: login credentials being compromised, device data collection and who has access to the data, usage data being sold to third parties and the device being hacked. The participants who had security concerns owned smart televisions (TVs), smart speakers, smart air fryers, smart blinds or a complete smart home set-up within their homes.

5.3 PRINCIPLES OF HUMAN-COMPUTER INTERFACE IN IOT DEVICES

The purpose of the research study was to understand the current user experience of smart home devices installed within households and the importance of the HCI element when designing IoT devices for end users. The study aimed to assist IoT device manufacturers and HCI designers to identify and address the current challenges and concerns raised by end users. The interview assisted with providing insights into the elements considered by Information Technology (IT) experts when designing an IoT device. The following social theory was utilised to analyse the research findings: cognitive load theory. To further understand the phenomena in depth, two data collection methods were used to gather data. Fifty-seven participants who reside in South Africa and owned a smart home device were requested to participate. The study required ten employees from the case study organisation to participate, to understand the current design process of IoT device build.

The theoretical framework used to analyse the research findings was the cognitive load theory. Cognitive load theory focuses on the amount of working and long memory available for an end user to perform a task or solve a problem. Within the HCI community, the focus has been on reducing the user's cognitive load by designing effective technology interfaces that decrease the extraneous cognitive load, which can then assist the end user to shift their attention to the main task (Oviatt, 2006). As highlighted by Al Siyabi and Al Minje (2021), cognitive load theory was initially used for new education material implementation but it is moving towards the HCI space for web-based learning. An extraneous cognitive load is generated when the presented information may not be suitable during the learning phase. When introducing a new technology product, end users are required to learn how to use the interface and over time learn how the product operates.

For addressing an aspect of the study, the researcher requested smart home device owners to describe their experiences with setting up and using their smart devices. The purpose was to understand the amount of effort and mental power that was required to use smart home devices. Almost all of the participants indicated that the smart device was easy to install and set up in their homes. The usage and management of smart home devices were marked as easy by the majority of the participants. Despite the installation and usage of the smart device being marked as an easy task, several participants raised challenges with using the smart home devices. The challenges (Refer to section 4.2.2.) that can be linked to cognitive load theory are the following:

1. Participants found the initial setting up challenging because the instructions provided by the device manufacturer were insufficient or the smart device was not available in South Africa. Setting up and installing may increase the cognitive load on the user's memory. Working memory is limited and therefore, an increase in cognitive load can lead to a negative experience with the device usage.
2. A participant had to master a new skill to enable them to set up the smart home device. This has an impact on cognitive load since the end users were unable to successfully use the device based on the (then) current information available to them.

3. Remembering the login credentials was also highlighted as a factor since the participants were required to retrieve information from long-term memory to use their devices.
4. The number of features available on the device overwhelmed the end user. This challenge may then lead to additional cognitive resources being required to navigate the smart device. This challenge, therefore, has an impact on the 'split-attention principle' which focuses on reducing the amount of information required to use the device.

IoT devices collect usage data and present the data back to end users for various reasons. The researcher requested the participants' experiences with viewing usage data for their smart home devices. The participants had mixed responses and less than half of the participants were neutral about the available data being useful and easy to comprehend (Refer to section 4.2.3.). Around 28% of the participants disagreed with the provided statement. Participants did not find the presented device usage information useful and easy to comprehend. Therefore, a lack of comprehension might require end users to make use of additional cognitive resources to process the presented data.

Semi-structured interview participants mentioned that the device usage information must be presented using the correct visualisation that caters to different literacy levels. The device usage information should focus on telling a story and educating the user in a simplified manner. Participants referred to Google with respect to educating users on what types of data will be collected and used. Accordingly, the research findings align with cognitive load theory.

5.4 REFLECTION ON CONTRIBUTION

In this section, the researcher discusses the research findings that can be added to the existing body of knowledge of the HCI field of study, how HCI practitioners can utilise Norman's design principles when building IoT devices for end users and lastly, the researcher will share their personal reflections on this research study.

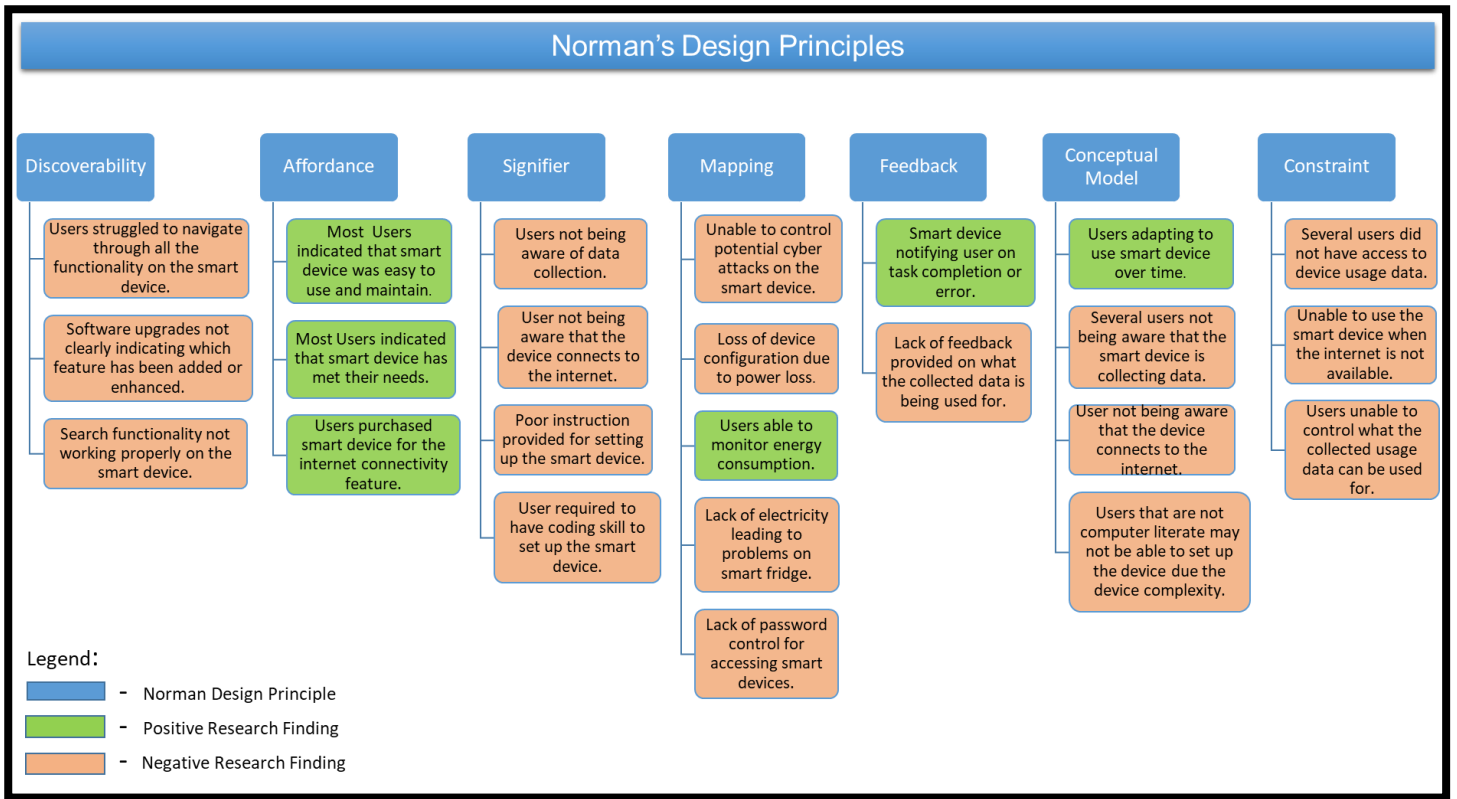
5.4.1 Body of knowledge

Chapter 2 covered the existing literature available on HCI applications when designing an IoT device. This research study assisted in identifying the end user's motive for utilising smart devices instead of traditional devices. HCI practitioners can use the identified purchase motive to understand end users' needs and wants. Based on the research finding, it can be noted that there are several IoT device usage challenges and concerns that need to be addressed by HCI designers to ensure that end users trust smart devices. HCI designers need to look for intuitive ways of addressing end-user concerns and challenges to ensure the successful implementation of smart devices in future. This study also assisted in indicating the crucial design components when building a smart home device. Much of the focus was on catering for end users with all levels of literacy and ensuring that only required usage data is collected to enhance user experience.

5.4.2 Practical application

Norman's eight design principles (Norman, 1998) were used to link the research findings results. The positive and negative research findings on using IoT devices were mapped out in Figure 15. The colour blue highlights Norman's design principles, the colour green indicates positive research findings and the colour red indicates negative research findings. IoT device designers should take the principles laid out below into account when designing smart devices for end users. For smart devices to be successfully implemented in any environment, it needs to meet useability requirements. A detailed explanation of all Norman's design principles is provided in Chapter 2.

Figure 15: Research Finding Mapping to Norman's Design Principles



5.4.3 Personal reflection

I embarked on this research journey to fully understand the current user experience with smart home devices in South Africa and what components were being considered by information technology (IT) experts when designing an IoT device for use by end users. Being in the technology industry, I have also been curious about the implementation of the IoT for different use cases and how it has been enhancing people's lives. By embarking on this journey, I have come to thoroughly understand the importance of building smart devices around end users' needs, as they become the sole managers and administrators of these smart devices. In talking to the research participants during the semi-structured interviews, I understood that design gaps still exist with the IoT and these need to be resolved by the device designers. The end user should not be treated as an external component of the design process.

5.5 FUTURE RESEARCH

This research study addressed two aspects. The first aspect focused on understanding the current user experience of IoT implementation within South African households. While the adoption of smart home devices is steadily growing, the need to address end-user concerns and struggles is prevalent. Smart television (TV) was identified as the most common smart device installed within a home. Despite the end users finding the installation and management of smart devices easy, several device usage challenges and security concerns were highlighted and addressed in this research. The second aspect of the research focused on incorporating HCI when building IoT devices and identifying elements that are crucial to consider when designing IoT devices. The findings were summarised and linked to cognitive load theory. Further research could be conducted to understand the implementation of IoT devices within different environments such as smart cities or industries within South Africa. While this research focused on the current implementation of smart home devices within South Africa, the future researcher could delve into understanding why South African households have not implemented smart home devices. This, in turn, could assist with identifying end users' resistance to implementing smart home devices.

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7 APPENDIX A – ETHICAL CLEARANCE LETTER



Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en
Inligtingtegnologie / Lefapha la Boetšenere,
Tikologo ya Kago le Theknolotši ya Tshedimošo

29 June 2022

Reference number: EBIT/18/2022

Miss S Waqar
Department: Informatics
University of Pretoria
Pretoria
0083

Dear Miss S Waqar,

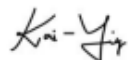
FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Approval is granted for the application with reference number that appears above.

1. This means that the research project entitled "Identifying Principles of Human Computer Interaction in IoT Devices: A South African Context" has been approved as submitted. It is important to note what approval implies. This is expanded on in the points that follow.
2. This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Research Ethics Committee.
3. If action is taken beyond the approved application, approval is withdrawn automatically.
4. According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.
5. The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.



Prof K.-Y. Chan

Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

8 APPENDIX B – SUPERVISOR LETTER OF APPROVAL



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering,
Built Environment and Information Technology

1956 – 2016
60
years of
Engineering Education

14 November 2022

To whom it may concern

Research proposal approved: Ms S Waqar

Ms Waqar (Student nr. 16185952) is registered for a MCom INF at the University of Pretoria.

Supervisor : Prof Hanlie Smuts

Research topic is: Identifying principles of human computer interaction in IoT Devices: A South African Context

I herewith confirm that Ms Waqar research proposal has been approved. She may continue with the planning of her data collection, as well as her ethics application.

Kindest regards

^m Prof MC Mathee
Postgraduate Coordinator: Informatics
012 420 6321

9 APPENDIX C – QUESTIONNAIRE

Informed Consent Form

1. Project information

1.1 Title of research project: Identifying principles of human computer interaction in IoT Devices : A South African Context

1.2 Researcher details:

Name – Saman Waqar

Email : u16185952@tuks.co.za

Cell : 0742332684

Department : Informatics

1.3 Research study description.

Project Description:

The purpose of the project is to study the principles of Human Computer Interaction (HCI) in smart home devices. The study will be conducted in South Africa and the participant required for the study are consumer's that possess a smart home device and Skilled experts that will provide feedback on what components are important in building an IoT device. The smart home device can be but not limited to the following type; Smart TV , Smart Camera , Smart Cooking Appliances, Smart Lighting , Smart Sensors, Smart Speakers and Smart plugs etc.

Project Objectives:

The main objective of the project is to study the benefits and challenges of using a smart home device , security and privacy concern related to the smart device and accessing the information generated by the smart device.

Participants Requirements:

The participant is required to do the following:

- o The survey can be completed during anytime that the participant is comfortable with.
- o Participant must volunteer to participate in the study.
- o Complete the consent form provided by the researcher in the survey link.
- o Complete the survey on the link shared by the researcher. Please note that the questions in the survey are related to usage of the smart home device. The research will be carried with integrity and maintain required confidentiality.
- o Notify the researcher that the survey has been completed.

Risk Involved with Participating in the Study:

There are no risk identified for participating in the study.

I hereby voluntarily grant my permission for participation in the project as explained to me by Saman Waqar. The nature, objective, possible safety and health implications have been explained to me and I understand them. I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication. *

Yes

No

Smart Device Information

What type of Smart home device do you have? *

- Smart TV
- Smart Refrigerator
- Smart Lights
- Smart Camera
- Smart Speaker
- Smart Sensors
- Smart Plugs
- Smart Lock
- Other: _____

How long do you have the Smart home device for? *

- 0 - 2 years
- 2- 5 years
- 5 - 7 years
- 7 years +

What Brand is the Smart Home Device? *

- Phillips Hue
- Amazon
- Arlo
- Eve Energy
- Google
- Nest Learning Thermostat
- August
- Other: _____

Why did you purchase the smart home device? *

N/A|

Back

Next

Clear form

Smart Device Usage and Maintenance

The smart device was easy to set up and install. *

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

The smart home device met my expectation and needs *

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

The smart home device is easy to use and maintain. *

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Please specify any challenges faced with using the smart home device. *

Your answer _____

How do you maintain and operate the smart home device? *

Via a Mobile Application

Via an Online Website

Via the Smart home device (e.g. Button built on the smart home device)

Other: _____

[Back](#) [Next](#) [Clear form](#)

Smart Device Data Collection

I am aware that my smart device collects usage data. *

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

I can access my smart home device usage data *

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

How do you access the device usage data? *

Via Mobile Application

Via an Online Webiste

Via the device (e.g. Screen built up on device displaying usage details)

Not Applicable as I do not have access to the device usage data.

The device usage data is useful and easy to comprehend. *

Strongly Agree

Agree

Neutral

Disgaree

Strongly Disagree

[Back](#) [Next](#) [Clear form](#)

Smart Device Security

I have security related concerns with using the smart home device *

Strongly Agree

Agree

Neutral

Disgaree

Strongly Disagree

Please specify the security concerns related to the smart home device. *

Your answer

[Back](#) [Next](#) [Clear form](#)

10 APPENDIX D – SEMI-STRUCTURED INTERVIEW

Informed consent form

1. Project information

1.1 Title of research project: Identifying principles of human computer interaction in IoT Devices : A South African Context

1.2 Researcher details:

- Name – Saman Waqar
- Email : u16185952@tuks.co.za
- Cell : 0742332684
- Department : Informatics

1.3 Research study description.

- Project Description: The purpose of the project is to study the principles of Human Computer Interaction (HCI) in smart home devices. The study will be conducted in South Africa and the participant required for the study are consumer's that possess a smart home device and Skilled experts that will provide feedback on what components are important in building an IoT device. The smart home device can be but not limited to the following type; Smart TV , Smart Camera , Smart Cooking Appliances, Smart Lighting , Smart Sensors, Smart Speakers and Smart plugs etc.
- Project Objectives: The main objective of the project is to study the benefits and challenges of using a smart home device , security and privacy concern related to the smart device and accessing the information generated by the smart device.
- Participants Requirements: The skilled expert participant is required to do the following:
 - Volunteer to participate in the study.
 - Each semi structured interview is planned to take around 30 – 45 minutes.

- The semi structured interview will be held online on Google meet.
 - The link for the meeting will be shared in a mail and the participant is required to join the meeting via the link.
 - Complete the consent form provided by the researcher in the meeting invite mail. The form needs to be completed before the interview begins.
 - The semi structured interview will be recorded online using the record tool on Google meet.
 - Please note that the participants personal data will not be included in the research finding.
 - Once the semi structured interview is concluded , the researcher will close off the interview with the vote of thanks.
- Risk Involved with Participating in the Study – There are no risk identified for participating in the study.

2. Informed consent

2.1 I, _____ hereby voluntarily grant my permission for participation in the project as explained to me by Saman Waqar.

2.2 The nature, objective, possible safety and health implications have been explained to me and I understand them.

2.3 I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.

2.4 Upon signature of this form, the participant will be provided with a copy.

Signed: _____ Date: _____

Witness: _____ Date: _____

Researcher: _____ Date: _____

Interview Template			
Candidate Name		Conducted By:	
Interview Date		Interview Start Time	
Position Title		Interview End Time	
Qualifications		Years of experience?	
Question Number	Question		Candidate Response
Question 1	How would you define IoT?	Answer 1	
Question 2	What is your understanding of the HCI concept?	Answer 2	
Question 3	Explain your experience with regards to usage of an IoT device.	Answer 3	
Question 4	What is your experience in relation to designing of an IoT device?	Answer 4	
Question 5	What are your thoughts on incorporating the human computer interaction component while designing an IoT device?	Answer 5	
Question 6	What are some of the elements you will consider when building an IoT device for end users?	Answer 6	
Question 7	What are your thoughts on the IoT data collection from end users?	Answer 7	
Question 8	The collected data by IoT device is presented back to user in a visualization form, what key points should be considered when presenting of the data back to the end users?	Answer 8	
Question 9	What are your thoughts related to security and data collection element?	Answer 9	

11 APPENDIX E – RESEARCH TITLE APPROVAL LETTER



UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Economic and Management Sciences
Student Administration

Our ref: 16185952
Contact person: Miss Lerato Krappie
Tel: +27 012420 5387
E-mail: lerato.krappie@up.ac.za

02 December 2022

Dear Ms Waqar,

APPROVAL OF TITLE REGISTRATION

I have a pleasure in informing you that the following title registration has been approved.

Identifying principles of human computer interaction in IoT devices: a South African context

Your enrolment as a student must be renewed annually until you have complied with all the requirements for the degree, preferably during the official period of enrolment but before **28 February**. You will only be entitled to the guidance of your supervisor if annual proof of registration can be submitted.

Yours sincerely,



For: **Prof Chitiga-Mabugu**
Dean Faculty of Economic and Management Sciences

12 APPENDIX F – LANGUAGE EDITING CERTIFICATE

Certificate of Editing

MCom in Informatics

*IDENTIFYING PRINCIPLES OF HUMAN-COMPUTER INTERFACE
IN IOT DEVICES: A SOUTH AFRICAN CONTEXT*

by

Saman Waqar



Edited for English language usage

*Lorinda Gerber
29th of November 2022*



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EDITORS
Guild

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13 APPENDIX G – LANGUAGE EDITOR MEMBERSHIP DETAIL



Lorinda Gerber

Associate Member

Membership number: GER003

Membership year: March 2022 to February 2023

072 125 9475

loredit.ele80@gmail.com

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