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ABSTRACT
This article offers perspectives on adopting smart home technology into usability testing for technical and professional communication (TPC) courses. Usability is a valued skill for technical communicators. However, usability testing methods have their problems as pedagogical tools. Internet-of-Things (IoT) devices and Smart Home Technology (SHT) may offer instructors tools to overcome some of those problems. This article details advantages and concerns associated with using SHT for curricular usability testing.

KEYWORDS
Usability testing; UX design; pedagogy; internet of things; smart home technology

Introduction

There is a longstanding link between technical and professional communication (TPC) and usability testing. Usability.gov defines usability testing as, "evaluating a product or service by testing it with representative users" (Usability testing, n.d., p. 1). Although initial research and publications in TPC largely focused on the usability of documents (Redish, 2010), and although some authors noted that technical communicators seemed to "dabble" in usability (Savage, 2003, p. 177), there is now an established track record of usability testing and research within the discipline. And as Savage (2003) points out, TPC's close alignment with IT programs places it in an advantageous position for usability testing. Part of the change is due to the fact that technical communicators' skill sets are well suited to designing usability tests and reports (Fisher, 1999; Redish, 2010). But part of that change is also due to the proliferation and adoption of electronic devices and the inherent confusion that comes with new electronic products.

The latest in the ever-expanding catalog of such devices are Internet-of-Things (IoT) devices and, specifically, smart home technology (SHT). IoT devices can be described as devices that can communicate and interact with each other via the Internet and adjust their environment. SHT devices are a specific type of IoT device designed for use within homes (e.g., temperature sensors, thermostats, lights). Smart homes are generally defined by having electrical devices that can communicate with one another or at least with a central hub or phone app. Aldrich (2003) provides one of the first definitions of such a home by saying that smart homes have intelligent objects, have communicative objects, are connected to networks, learn from activity patterns, and pay attention to our activities (not all objects do all of those things, but most do). Modern "smart" devices are also capable of receiving remote commands, communicating with each other, and taking action (such as adjusting a thermostat) on their own. As Porter and Heppelmann (2014) explain, smart connected products have three basic components: physical, smart, and connectivity components. Physical components are those that make up the device – for example, the deadbolt on a smart door lock. Smart components are those that process information and respond to commands such as the command from a cell phone app to unlock the door. Finally, connectivity components are those that allow the connection between the phone and the door, or between many devices in the room, which may all communicate with one another.

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Smart homes tend to be viewed as a synergistic relationship among human, home, and technology (Saizmaa & Kim, 2008). However, although the devices can communicate among themselves quite easily (when properly installed), their communication with humans still leaves much to be desired. For example, SHT frequently misinterpret commands, their interfaces can be time consuming and difficult to navigate, and the proper methods (voice command, phone app, hub interface) for accomplishing a task are at times shrouded in mystery.

Our research team first began testing SHT in 2017. We began by testing SHT in a living laboratory environment within a village of student-designed homes (Wright & Shank, 2019; Wright, Shank, & Yarbrough, 2022). We have also completed survey research concerning the perceived benefits and knowledge of SHT (Shank, Wright, Lulham, & Thurgood, 2021). Our primary findings from those studies indicate that while users expect major lifestyle enhancements from SHT and have a high opinion of the devices, they seldom go out of their way to learn about the devices, even after training. Nevertheless, users continue to have a high opinion of the devices. Eventually, however, our research team moved into lab-based testing because we were unable to observe users' interactions with the technology. Our move to lab-based testing also allowed us to begin considering how SHT might be used as part of the TPC curriculum.

At this point it is worth noting that what our research team has been practicing is not solely usability research but also UX research, in that we are not simply interested in the functional aspects of the product but also in users' emotional responses to SHT. The European Committee for Standardization's ISO 9241 defines usability as, "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (undefined, p. 1). ISO 9241 also defines user experience, calling it, "A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service" (undefined, p. 1). While our research team is interested in things like error rates and time on task, we are also keenly interested in user perceptions of SHT, especially perceptions of the interfaces that are now expressly devoted to controlling SHT. Those interfaces present another new navigational scheme for users, and SHT cannot be fully utilized without them. Our research (Shank, Wright, Nasrin, & White, 2022) has taught us that efficiency and effectiveness are important with SHT, but also that users' emotional responses to problems can have an even greater impact on their acceptance or rejection of that technology (refer to Norman, 2004). So, just as Redish (2010) pointed out that UX and TPC had become intertwined, usability testing and UX design have become intertwined with SHT.

There is good deal of recent TPC research dealing with IoT devices. For example, Fagerjord (2017) argues that rhetoric should be used as a tool in designing locative experiences produced by smart watches and other IoT devices, as those devices are often used to indicate what is special about a certain time and place. Frith (2017) discusses the TPC required to interpret big data and to make smart cities operate. Tham (2018) provides an extensive literature review of TPC sources on mobile devices and interactivity and presents seven areas of consideration for their design. Verhulsdonck, Melton, and Shah (2019) address acceptance and rejection of IoT devices by offering an expanded vision of how humans connect and disconnect from IoT networks. And Johnson-Eilola and Selber (2022) discuss the impacts of an IoT student competition and how the concept of assemblage relates to the narrowing gap between users and devices. As they point out, those devices now have agency and can provide complex services. If anything, IoT devices have greatly decreased the gap between users and their devices. Indeed, those devices can now be designed to share goals with their users.

SHT offers many potential benefits for users. Typical SHT examples include lights that can turn off and on or change colors, thermostats that can be controlled remotely, televisions and other appliances that can be controlled via voice command or phone app, and security cameras/door locks that can be controlled in the same manner. However, at this point the list of available devices includes all manner of gadgets including window blinds, pet trackers, sprinklers, and sensors that can detect humidity or carbon monoxide levels. Those devices can be routed through a central hub so that they may communicate with one another. Or, with newer equipment, many of the devices run on simple Wi-Fi signals, allowing constant communication among them. For those who aren't familiar with the systems, what this means in practice is that one might tune the TV to a certain movie with a simple voice command, or by using multiple devices simultaneously, issue a command such as "bedtime" which would cause all window blinds to close, doors to lock, security systems and cameras to become operational and record video, and all household lights to shut off. The same thing, in most cases, can be done with a cell phone app from remote locations.

Much has been written about SHT, especially concerning its security and privacy problems, its design and functionality, and its predicted role in the home of the future. However, surprisingly little research existed on the human aspect of SHT until the past few years. It is interesting to note that SHT has been predicted as "the next big thing" for many years, and only recently have authors begun to note that it is not living up to the hype (Keeping, 2019). Takahashi (2017) reports that 81% of consumers are aware of smart homes, but only 26% want one. That is not to say that people aren't buying the devices. Millions are now being sold. However, manufacturers of SHT have been much more adept at marketing devices than in supporting them. Even now, a quick trip to any major manufacturer's website will be met with rhetoric akin to "just plug it in and watch the magic happen" (not true, I'm afraid – but getting better all the time). In fact, setting up SHT devices can be more frustrating than using them.

At the same time, usability has not been a readily apparent priority for SHT manufacturers. In fact, most of the same manufacturers seem to be relying on YouTube as their technical support center. Many researchers have maligned SHT for its security issues and, ironically, have pointed to privacy as a major concern while security is perceived by users as a major benefit (refer to Hugo et al., 2020). It's true that privacy threats do exist, but in my experience the thought that security concerns prevent adoption of SHT is misleading. Privacy issues are a concern for SHT users, but usability problems are even more pervasive. Many a would-be SHT user has put their devices back in the closet after failed attempts to create "the magic" (Shank, Wright, Lulham, & Thurgood, 2021). One of the few long-term residential studies conducted recently found that, although many expectations of living with SHT for one year were met, "new issues arose relating to the usability of some components and the time and effort required to configure them" (Oliveira, Mitchell, & May, 2019, p. 613). SHT research has mainly focused on security, privacy, and design concerns, overshadowing the usability problems that are a more direct concern for many users.

That is not to say that there is no hope for solving usability problems with SHT. Research on SHT, like usability studies, is becoming more interdisciplinary. Social psychology (Karimova, Shirkhanbeik, & Alvares, 2015; Kim, 2016), computer science (Gunawan et al., 2017; Lee, Kwon, Lee, & Kim, 2017), anthropology (Brown, 2015; Gram-Hanssen, 2019) and a host of other disciplines are beginning to contribute to the research in ways that may improve usability and increase long-term adoption of SHT devices. Each discipline has its own view of IoT and SHT devices, but taken together they form a more complete picture of the whole. In fact, our own SHT research team includes representatives from TPC, social psychology, and architectural engineering. Technical communicators, in particular, would seem to have much to contribute. Unlike usability testing for software or hardware IT components,

> IoT tests present complications due to the heterogeneity and distributed nature of their components. Functional testing and performance evaluation must be done before deploying IoT in a production environment. Taking this into account, the real interaction with the physical world needs to be observed, unlike common software testing methods. (Cortés, Saraiva, Souza, Mello, & Soares, 2019, p. 8)

This set of circumstances would seem to lend itself well to the set of skills possessed by technical communicators, according to the literature in our discipline. With careful planning, SHT devices can be used to reinforce both beginning and advanced usability-testing courses.

While SHT devices can still be difficult to install and to operate, they offer a new opportunity for TPC scholars and educators to incorporate cutting-edge technology into usability studies at a fraction of their original cost. Therefore, the time may be right for many TPC instructors to consider new, innovative approaches to conducting course-based usability testing. This article offers advice for adopting SHT into that testing by considering past criticisms of usability testing in courses, by examining the role of IoT devices in correcting those problems, and by offering specific advice for adding IoT devices to course-based usability testing.

Problems with usability testing and course applications

Many past criticisms of usability studies in TPC curriculum, such as students using various devices that they don't understand (Zhou, 2014), completing purely summative testing (testing a product at the end of its development cycle) (Zhou, 2014), and working with products that they cannot physically engage with (Chong, 2016) can be addressed by utilizing SHT. IOT devices are not unlike software programs of the 1980s, in that they are flawed and system based rather than user centered. That is changing, but many of the devices still have a long way to go.

As Lanier (2018) notes, surveys of practicing technical communicators reveal that changing technological tools are atop their list of concerns about the future. This concern might lead us to believe that even our own tools need usability testing. However, the fact that there is a history of usability testing and research within TPC does not eliminate the problems with usability testing overall. The most common complaint against usability testing is that summative testing (testing a product at the end of its development cycle) offers little chance for a product to be improved (Lewis, 2014). Why test a product that is finished and ready to market if there is no hope of improving it? This limitation has been particularly prevalent in the software industry. It is also a common problem for technical editors, who are often given a document at the end of the development cycle when it is too late to make major changes that might improve usability (Cunningham, Malone, & Rothschild, 2020).

As a technical communicator, researcher, and practitioner, I personally encountered this problem. In my experience, a company that is existing on investment capital and racing to market has little use for backtracking to improve usability. More often than not, suggestions for improvement are met with comments such as, "It doesn't work that way" even when it should work that way. The translation of that statement is, "You may be right but we're not going to risk breaking something else in order to fix those things." Of course, my involvement began only at the tail end of the development cycle. Redish and Barnum (2011) echoed those thoughts:

> Yet, anecdotal evidence from my former students and gleaned at technical communication conferences suggests that technical communicators have not generally been invited to take a seat on the development team or as part of a user research team. This tendency to exclude or ignore the technical communicator manifests itself in one of two ways:
>
> (1) The technical communicator is not brought into the development process (including usability testing of the product in development) in time to effect positive change in the user experience, or
> (2) When the development process does not include usability testing, the technical communicator's call for usability testing is ignored (not funded or approved). (p. 97)

Another problem is that many people confuse informal testing of small sample sizes with more formal, replicable studies. Dicks (2002) discusses the misinterpretation of usability tests and results at length, arguing that inferential statistics are often misinterpreted as universal truths for much larger sample sizes. Rubin (1994) also lamented the credibility given to some types of studies and results, saying that participants and testing environments can never be truly representative of real-world use. Similar themes and criticisms can be located easily in the literature and conference proceedings of various disciplines. Dunn and Hayes (2020), for example, note that examinations of UX interface tests reveal that tests are often compared to one another despite different methodologies and results, and that usability testing is not universally superior to other methods.

Another problem is the way that usability testing is conducted in university courses. Zhou (2014) details a list of problems with course-based usability testing including that:

- Students test completed products, giving students the impression that usability doesn't involve building things.
- Students gain no appreciation of how a product is designed, which frames testing as an activity with little agency.
- Organizational settings and business practices are ignored.
- Students often choose products they have little knowledge of.
- Usability testing often comes too late in the curriculum to be incorporated into existing knowledge.
- Tools are often prioritized over communication skills.

Those are all valid criticisms and are grounded in the practices advocated by much of TPC literature. Chong (2016) conducted a thorough review of that literature, focusing on the inherently messy nature of usability testing and the implications for courses. Chong's conclusions show that usability testing in TPC courses is only effective if:

- Students learn to customize testing methods to their individual projects.
- Students have time to examine and learn the context-specific processes and project management issues associated with testing (collaboration, recruiting and negotiating with subjects).
- Students are given strategies for enacting usability methods rather than just high-level descriptions of those methods.

As Chong (2016) says, most texts are still advocating the need for usability testing rather than teaching the rhetorical skills needed to navigate testing and to view it as more than a procedural exercise.

Despite the many criticisms of usability testing and its pedagogical applications, usability testing courses and units within other courses continue to be widespread and popular because they provide much needed skills for many disciplines. Usability units are especially popular in courses for non-majors, where perhaps only a few weeks can be devoted to those activities. However, if SHT is integrated into existing courses, the activities required to create the various testing documents can replace other assignments, thereby allowing more time to be devoted to the process.

There are quite a few sources in TPC literature that can help with integrating those activities. Summers and Watt (2015) describe methods for pairing rhetorical practices and usability practices. Their methods include designing tests for and revising documents and paper-based prototypes of mobile applications. In addition, they use two different methods: one in which students started from scratch and one in which they used existing products and methods. Their result showed that starting from scratch led to high student investment, while the second resulted in better written results. However, both methods met their approval. Other articles have described methods for having students write test scripts and informed consent forms (Schneider, 2005) and methods for testing user manuals (Maynard, 1982). There is a myriad of suggestions available for incorporating usability activities into TPC courses, but unless an instructor is lucky enough to know of a development process taking place on campus or a local business that doesn't mind regular interruptions of ongoing for-profit activities (some might actually appreciate the help), many of the problems mentioned by Zhou (2014) and Chong (2016) persist. But one recent addition to the technological landscape, SHT, can provide a more interesting experience for students while alleviating some of those problems.

Using IoT devices in TPC courses

One of the current advantages to using SHT for teaching and research is that the prices of the devices have decreased substantially. Acharya (2022) notes that budgetary concerns can be a major obstacle for

TPC usability pedagogy. Price was also initially seen as a major obstacle by both consumers and academic researchers, but manufacturers have worked hard to reduce those prices to gain a foothold in the mainstream market. Our research team was able to equip a usability lab with smart home equipment for approximately $2,500. That lab includes the following smart devices:

- Google Nest Hub Max
- Smart thermostat
- Smart television
- Smart, tunable (color-changing) lights
- Smart doorbell
- Indoor security camera
- Smart door lock
- Cellular telephones with equipment-controlling apps
- Video camera
- Computer

Figure 1. Images from the “bat cave.”.

The ability to use a small space is also a major advantage of smart home equipment. Our lab, affectionately referred to as the “bat cave” (Figure. 1) within the department, is just a small room with lots of technology in it. However, by adding a couch, desk, a few end tables, and a TV stand, we were able to approximate a small living room, again at relatively little expense. That is a huge advantage on campuses where space is always at a premium and money is tight, because it eliminates the need for a traditional usability lab (control room, seating, monitors, etc.) but provides many of the same testing benefits.

At the same time, users can perform tasks with the equipment that closely approximates their real-world environment. For research, the advantages of that situation are clear, but for teaching this realistic testing environment also offers distinct advantages. First, students can all use the same devices for testing. As Zhou (2014) says, students often choose their own devices to test in usability courses and don’t understand them well. This situation can lead to multiple problems, including devices that aren’t truly suitable for testing and testing locations that are unrealistic for the product. In many cases an instructor has little control over that, simply because the student has to test *something* and there is no general usability space available for testing. Therefore, a small investment in equipment allows for a centralized location, similar testing protocols, and provides tools that can be mastered by students prior to running their own tests.

Also, testing in a controlled but unique smart home environment more closely approximates developmental testing. Usability is a valuable part of TPC courses because it offers students a chance to conduct research and to work with real data generated from research. While that works well, even in the form of discount testing (Rubin, 1994), with a small number of users and a short timeframe, it is typically limited to testing either web sites, information visualization platforms, or basic software that can be found in the most readily available campus computer lab. None of those options offer test takers anything that they haven't seen before, technologically speaking. They are simply variations on a theme, or worse, something that they have used before. Conversely, smart home devices are typically new to students who participate in tests. Some may already own a device such as Amazon's Echo, but most have never used it to do anything more than play music or answer simple questions. Therefore, controlling devices, or better yet controlling multiple devices simultaneously, is an entirely different experience for them. Students designing tests also have time with SHT to customize testing methods to their individual projects as called for by Chong (2016)—not because their projects are so varied but because discussion can be held over a single type of equipment and what might be best for testing that equipment.

It's true, of course, that this is actually summative testing with completed products. But those products are far from perfected at this point and if not for economic considerations, would probably still be in development. So SHT offers a chance to test an imperfect product that is still evolving. In effect, then, the testing is not summative testing, and testing results may influence the development of those products when shared or published.

Finally, SHT offers both test administrators and users a chance to work with products that they can physically interact with. I've often thought that it would be fun to test something else that most students are unfamiliar with such as a jack hammer, simply because they could feel the vibrations and take in the effects of the machine. Sadly, this idea is hardly practical on a university campus and probably dangerous as well. But at least with something like a smart door lock, users can see and hear the deadbolt opening. It is a small difference maybe, but the satisfaction during testing is evident on their faces. Even when working with visual information platforms such as flightradar24.com, students don't really know what is happening. There is nothing tactile, only new information in response to given information. Finally, if you are working with students in computer or electrical engineering disciplines in TPC service courses, SHT products are probably closer to something they might actually design in the future, rather than a web site.

Methods and student testing

Although the nature of SHT testing is a bit of a different animal than other types of testing, some of the same strategies still apply. Personas, concurrent think-aloud protocols (CTAP), screening questionnaires, and pre- and posttest questionnaires are all still great tools, and discussing their design should still be a big part of the process. If you are new to testing in general, Barnum's (2020) *Usability Testing Essentials . . . Ready, Set, Test* is a great place to start with those tools and general methods. At the very least, students will need to complete the following:

(1) Identify and profile an audience
(2) Create a consent form for testing
(3) Define scenarios
(4) Create a task list (Appendix B)
(5) Create a checklist for the test moderator (Appendix A)
(6) Create a posttest questionnaire (Appendix C)

Students should also be well versed in audience analysis. In my experience, small studies (20 participants or less) produce much better results when test participants are homogenous and must be representative of potential users. A good place to start with audience analysis and selection is Baxter, Courage, and Caine's (2015) *Understanding your users: A practical guide to user research methods*. There are excellent tips for creating user profiles, personas, and scenarios that can really help to kickstart a project.

Tasks should be written in active language telling the user to do something without telling them *how* to do something. For example, "Turn on the couch lamp by selecting it from the Living Room section of the Google Home App on the cell phone" is not a task at all. It is an instruction. Such tasks only test the user's ability to follow instructions. It is much more enlightening to simply say, "Turn on the couch lamp" and watch what happens. Users may try to use a voice command, the Nest Hub, or the cell phone, and may look with various menus to do so.

Ideally, screening questionnaires, pre- and posttest questionnaires, a test moderator script, and a consent form will all be developed as a group before testing begins (refer to supplementary file 1 for a sample posttest questionnaire). The test moderator script is especially important, as it tells the student in charge of testing exactly what to do each time a test is administered – and more importantly after it is administered (refer to supplementary file 3 for a sample script). It can be surprisingly easy to forget little things when dealing with multiple devices, which are invariably altered during the course of a test. For example, if you turn a light blue and unlock the door, they will remain that way unless they are returned to their original state (hard to turn a light blue when it's already blue).

However, for SHT testing there are some differences. For student test administrators, it is imperative that they be familiar with scenarios and the task list first and foremost (refer to supplementary file 2 for a sample scenario and task list). However, it is equally important that students spend time with the equipment and its different modes of interaction so that they understand what works and what doesn't. That knowledge is especially important with SHT because a test may come to a standstill if equipment malfunctions or is improperly configured, which is unlikely to occur with something like a web site. For example, with the Google Nest Hub Max, we were able to turn on the television only with a voice command (not by using the cell phone or hub interfaces). It's important to understand that type of limitation going into testing. Otherwise, that limitation may be misinterpreted as an equipment malfunction. One strategy that works well is to have students complete a usability test themselves before test development begins. That way, they can experience firsthand what it is like to complete the test before they understand the equipment.

Also, you need to record everything. Testing SHT requires both physical action as well as digital input from participants. There are free apps that can be used to record the cell phone screen during the test, and a well-placed video camera can capture both the hub interface and comments (think aloud protocol) made by users during the test. It is vitally important that student researchers understand both the screen-recording app and the video camera. We have had several instances of lost data simply because those recordings were not captured properly. Recording both visual interfaces and comments made by the users is the only way to examine them later in my experience. You just can't take enough notes during a test to do it justice. Separate phone and video camera recordings can be mixed after testing with video software (not that difficult, I promise) to create one recording with all data. Otherwise, there is little special equipment required by student researchers.

A 2010 special issue of *IEEE Transactions on Professional Communication* includes articles that further solidify the role of technical communicators in clarifying multidisciplinary complex problems (Redish, 2010) and in using specific qualitative methods such as CTAP, meaning to ask test participants to verbalize their thoughts while performing test tasks. Cooke (2010) shows that rhetorically grounded CTAP can be an effective method for investigating technology in TPC settings, and CTAP is still a heavily relied upon method for technology testing. The introduction to that issue, edited by Still and Albers (2010), also argues for keeping qualitative and cultural methods intact within usability testing.

It can be difficult for users to describe everything that they are thinking while they are both manipulating a phone app or visual interface and hearing auditory feedback (Hura, 2017), but administrators need to keep them talking – by asking what they are thinking if necessary, during the test. Even when users have experience using cell phone apps and touch screen interfaces, they are often using entirely new interfaces, causing their thoughts to be consumed by navigating those interfaces. In addition, it can be difficult for users to both annunciate their thoughts and intentions while giving commands to a voice assistant such as Amazon's Echo. So, considerations should be made for how to approach those tasks alongside CTAP.

A purely scientific approach to SHT testing is also not desirable because only testing that occurs during development can truly change products (Johnson, Salvo, & Zoetewey, 2007). Acharya (2016) further argues that usability testing can improve the value of products, but only if users are part of the development process. In this sense, value is not defined monetarily, but as a user experience that has value based on its efficiency and the experience of using a product. This is especially true of SHT as opposed to a software application like Microsoft Word, which is long past any major revisions. Therefore, test participant comments with SHT often prove to be the most valuable information gained during the test. Their comments also prove to be invaluable during analysis.

It is also even more important with SHT to keep the rhetorical nature of the process intact. Despite the new gadgetry, results from testing still need to be analyzed from a rhetorical perspective. It is easy to be seduced by the seemingly scientific nature of that equipment and consider only task completion and time as relevant data. However, because SHT is a new technology, how the people using that technology *feel* about using it often can tell you more than quantitative data. As Johnson, Salvo, and Zoetewey (2007) discuss, both replicable scientific method and rhetorical analysis must coexist for quality usability to take place. As they say, the realm of the probable is where real testing takes place. But students should be looking for trends in quantitative data and how those correspond with trends in qualitative data. For example, when you notice long task times and frequent errors coupled with primarily negative comments, you know you identified a trending usability issue. What people do is often useless unless they are telling you why they are doing it at the same time. Student researchers need to be keenly aware of that fact during testing. And if you must choose between quantitative and qualitative, the qualitative data will always tell you more.

If these protocols can be followed properly, students can have a much more rewarding experience than they would by completing testing on their own. First, because they are all using the same equipment, that equipment can be discussed and modified as a group. Second, students will be using equipment that they can physically interact with. Third, students can use course activities to better understand the equipment they are testing (as suggested by Chong, 2018). And finally, the data set that can be shared among the class is much more robust than what can be achieved in a similar time frame through individualized testing of different products. For example, a more rigorous test conducted with one participant per class member may yield 25 completed tests whereas students working individually can probably only test 3–5 subjects. Students can then discuss their results and pool their resources to gain more insight into a single system, rather than discussing small tests of different systems.

Limitations, warnings and suggestions

While there are exciting possibilities available with SHT usability testing, there are also some hard lessons to be learned along the way. With any luck, I can help you avoid the frustration and embarrassment I experienced. Here is some advice for beginners:

Campus Wi-Fi is a tricky animal

Because most homes have secure wireless routers, devices in the home are tuned to that signal, and devices from nearby homes are unable to connect to that router. This situation makes for a nice, smooth-running experience. On a campus, however, there is often one predominant Wi-Fi signal flying around everywhere with hundreds of devices bouncing signals all over the place. Usually, that doesn't really matter, and we don't even notice it. However, when SHT devices in different settings share a Wi-Fi network, all sorts of pandemonium ensues. When we first began studying SHT, we settled on a small campus village of occupied houses for long-term testing (Wright & Shank, 2019). We dutifully installed our SHT in the houses and, not realizing what their connection to a single Wi-Fi network would mean, decided to test the door lock in one of the houses first. Imagine our horror when every door in the neighborhood simultaneously unlocked. People were literally coming out onto their porches with scornful looks on their faces. Fortunately, as we have learned, most campus IT departments can and will install a local Wi-Fi network in a lab or home for a small fee ($150 in our case). It is a worthwhile investment that will make your equipment run much better and spare you all sorts of embarrassing confusion.

Physical facilities people have rules

You might think that replacing the 1970's model thermostat in your own "bat cave" with a brand-new smart thermostat would be looked upon as a favor. Nope. Physical facilities people like things just the way they are, thank you. And you'll find the same to be true with doors, overhead lights, and just about anything else that is hardwired into the campus system. So don't be surprised when you need to get a little creative with these things. Go get yourself a plain door from the clearance rack at the hardware store and lean it against a wall. You can still install a battery-powered smart lock in it. Likewise, buy the cheapest lamp you can find and put your expensive light bulb in that. The point is to check these things out ahead of time. You can save yourself some hassle but not all of it. We've done three separate installations at this point and all of them have had problems.

Installation is still difficult

Our original plan for the latest lab study was to have users do the installation themselves. As soon as we had completed the installation ourselves (purely for our own benefit at the time), we realized that it was impossible. SHT manufacturers still spend much more time marketing SHT products than they do supporting them. Put simply, their pitch is better than the execution. You cannot expect to just plug things in and have them all work perfectly. So, plan to spend some time educating yourself or find a knowledgeable colleague to help with that.

You will also want to consider accounts and logins. Typically, it's better to create new accounts that can be used by all. For example, you will need to log in to a Google or Apple account to successfully use and install Android or Apple phone apps.

It doesn't need to be perfect

One of the great things about usability testing is how comical it can be. You never really know when a user or the equipment will do something totally bizarre. We tend to look on these things as great results. They are the occurrences that really let you know where these products stand. The complaints against usability testing discussed above have been well documented. Yet, even in the "real world," testing with *anyone* is better than no testing at all. Is it imperative to discuss participant-selection methods, recruiting, project management, and methods? Sure, it is. Is it desirable to work those things into a usability-testing course? Sure, it is. Does it have to be perfect to be relevant and beneficial? No, it doesn't.

Conclusion

Smart home technology offers a new and increasingly affordable method for conducting usability testing in TPC courses. I do understand that not every reader will be able to find space to create their own "bat cave" and that not every reader will have the funds to purchase SHT equipment. However, simpler versions of this type of testing can be done with only a smart home assistant such as Amazon's Echo (Alexa). Those tests can be conducted in a classroom (as opposed to a lab) and still offer some of the same benefits. Consider the model used by Budiu and Laubheimer (2018) or methods used by Bogers et al. (2019) for a replicable classroom study that will be much more interactive and group focused than traditional individual tests. A quick visit to Amazon's site (https://www.amazon.com/b?ie=UTF8&node=21576558011) can also tell you of the many possibilities for tasks that can be assigned.

Using SHT to conduct usability testing offers advantages that can help overcome some of the traditional criticisms of usability testing, while offering an exciting new perspective. Using SHT devices for course-based testing can help to overcome small sample sizes by combining results, avoid purely summative testing by working with products that are not yet perfected, create better validity through standardized methods, simulate real-world use, approximate iterative product design, and prioritize communication over tools by giving students tactile devices to work with. It is by no means perfect and by no means free. But falling equipment prices, space-saving attributes, methodological advantages, and the ability to consolidate projects make SHT testing a viable alternative to many current project designs.

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References

Acharya, K. R. (2016). User value and usability in technical communication: A value proposition design model. *Communication Design Quarterly*, *4*(3), 26–34. doi:10.1145/3071078.3071083

Acharya, K. R. (2022). Promoting social justice through usability in technical communication: An integrative literature review. *Technical Communication*, *69*(1), 6–26. doi:10.55177/tc584938

Aldrich, F. K. (2003). Smart homes: Past, present and future. In R. Harper (Ed.), *Inside the smart home* (pp. 17–39). London: Springer.

Barnum, C. M. (2020). *Usability testing essentials: Ready, set... test!*. Cambridge, MA: Morgan Kaufmann.

Baxter, K., Courage, C., & Caine, K. (2015). *Understanding your users: A practical guide to user research methods* (2nd ed.). Waltham, MA: Morgan Kaufmann.

Bogers, T., Al-Basri, A. A. A., Ostermann Rytlig, C., Bak Møller, M. E., Juhl Rasmussen, M., Bates Michelsen, N. K., & Gerling Jørgensen, S. (2019, March). A study of usage and usability of intelligent personal assistants in Denmark. In *International Conference on Information* (pp. 79–90). Cham, Switzerland: Springer.

Brown, J. N. A. (2015). *Anthropology-based computing: Putting the human in human-computer interaction*. Cham, Switzerland: Springer.

Budiu, R., & Laubheimer, P. (2018). Intelligent assistants have poor usability: A user study of alexa, google assistant, and siri. Retrieved from https://www.nngroup.com/articles/intelligent-assistant-usability/#:~:text=Intelligent%20Assistants%20Have%20Poor%20Usability%3A%20A%20User%20Study,short%20answers.%20Users%20have%20difficulty%20with%20anything%20else.

Chong, F. (2016). The pedagogy of usability: An analysis of technical communication textbooks, anthologies, course syllabi and descriptions. *Technical Communication Quarterly*, *25*(1), 12–28. doi:10.1080/10572252.2016.1113073

Chong, F. (2018). Implementing usability testing in introductory technical communication service courses: Results and lessons from a local study. *Ieee Transactions on Professional Communication*, *61*(2), 196–205. doi:10.1109/TPC.2017.2771698

Cooke, L. (2010). Assessing concurrent think-aloud protocol as a usability test method: A technical communication approach. *Ieee Transactions on Professional Communication*, *53*(3), 202–215. doi:10.1109/tpc.2010.2052859

Cortés, M., Saraiva, R., Souza, M., Mello, P., & Soares, P. (2019). Adoption of software testing in Internet of Things: A systematic literature mapping. *Proceedings of the IV Brazilian Symposium on Systematic and Automated Software Testing* (pp. 3–11). doi:10.1145/3356317.3356326

Cunningham, D. H., Malone, E. A., & Rothschild, J. M. (2020). *Technical editing: An introduction to editing in the workplace*. Cary, NC: Oxford University Press.

Dicks, R. S. (2002, October). Mis-usability: On the uses and misuses of usability testing. In *Proceedings of the 20th annual international conference on Computer documentation* (pp. 26–30). Toronto, Canada: ACM. doi:10.1145/584955.584960

Dunn, P. G., & Hayes, A. (2020, July). The problems with usability testing. In *Proceedings of the International Conference on Human-Computer Interaction* (pp. 420–430). Copenhagen, Denmark: Springer. doi:10.1007/978-3-030-49059-1_30

Fagerjord, A. (2017). 13 Toward a rhetoric of the place: Creating locative experiences. In L. Potts & M. J. Salvo (Eds.), *Rhetoric and experience architecture* (pp. 225–240). Anderson, SC: Parlor Press.

Fisher, J. (1999). Improving the usability of information systems: The role of the technical communicator. *European Journal of Information Systems*, *8*(4), 294–303. doi:10.1057/palgrave.ejis.3000338

Frith, J. (2017). Big data, technical communication, and the smart city. *Journal of Business and Technical Communication*, *31*(2), 168–187. doi:10.1177/1050651916682285

Gram-Hanssen, K. (2019). Automation, smart homes and symmetrical anthropology: Non humans as performers of practices? In C. Maller & Y. Strengers (Eds.), *Social practices and dynamic non-humans* (pp. 235–253). Cham, Switzerland: Palgrave Macmillan.

Gunawan, T. S., Yaldi, I. R. H., Kartiwi, M., Ismail, N., Za'bah, N. F., Mansor, H., & Nordin, A. N. (2017). Prototype design of smart home system using Internet of Things. *Indonesian Journal of Electrical Engineering and Computer Science*, *7*(1), 107–115. doi:10.11591/ijeecs.v7.i1.pp107-115

Hugo, N., Israr, T., Boonsuk, W., Miloud, Y. B., Cloward, J., & Liu, P. P. (2020, February). Usability study of voice-activated smart home technology. In *International Conference on Remote Engineering and Virtual Instrumentation* (pp. 652–666). Athens, USA: Springer. doi:10.1007/978-3-030-52575-0_54

Hura, S. L. (2017). Usability testing of spoken conversational systems. *Journal of Usability Studies*, *12*(4), 155–163.

ISO 9241-11. (2018). Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts. Retrieved from https://www.en-standard.eu/csn-en-iso-9241-11-ergonomics-of-human-system-interaction-part-11-usability-definitions-and-concepts/#:~:text=EN%20ISO%209241-11%20Ergonomics%20of%20human-system%20interaction%20-,products%29%20and%20services%20%28including%20technical%20and%20personal%20services%29.

Johnson, R. R., Salvo, M. J., & Zoetewey, M. W. (2007). User-centered technology in participatory culture: Two decades "beyond a narrow conception of usability testing. *Ieee Transactions on Professional Communication*, *50*(4), 320–332. doi:10.1109/tpc.2007.908730

Johnson-Eilola, J., & Selber, S. A. (2022). Technical communication as assemblage. *Technical Communication Quarterly*, *32*(1), 1–19. doi:10.1080/10572252.2022.2036815

Karimova, G. Z., Shirkhanbeik, A., & Alvares, C. (2015). Society of things: An alternative vision of Internet of things. *Cogent Social Sciences*, *1*(1). doi:10.1080/23311886.2015.1115654

Keeping, S. (2019). Me not smart: Connected home tech isn't living up to the hype. *Cabling Installation and Maintenance*. Retrieved from https://www.cablinginstall.com/standards/article/16479561/me-not-smart-connectedhome-tech-isnt-living-up-to-the-hype.

Kim, K. J. (2016). Interacting socially with the internet of things (IoT): Effects of source attribution and specialization in human–iot interaction. *Journal of Computer-Mediated Communication*, *21*(6), 420–435. doi:10.1111/jcc4.12177

Lanier, C. R. (2018). Toward understanding important workplace issues for technical communicators. *Technical Communication*, *65*(1), 66–84.

Lee, B., Kwon, O., Lee, I., & Kim, J. (2017). Companionship with smart home devices: The impact of social connectedness and interaction types on perceived social support and companionship in smart homes. *Computers in Human Behavior*, *75*, 922–934. doi:10.1016/j.chb.2017.06.031

Lewis, J. R. (2014). Usability: Lessons learned ... and yet to be learned. *International Journal of Human-Computer Interaction*, *30*(9), 663–684. doi:10.1080/10447318.2014.930311

Maynard, J. (1982). A user-driven approach to better user manuals. *Ieee Transactions on Professional Communication*, *PC-25*(1), 16–19. doi:10.1109/TPC.1982.6447737

Norman, D. A. (2004). *Emotional design. Why we love (or hate) everyday things*. New York: Basic Books.

Oliveira, L., Mitchell, V., & May, A. (2019). Smart home technology—comparing householder expectations at the point of installation with experiences one year later. *Personal and Ubiquitous Computing*, *24*(5), 1–14. doi:10.1007/s00779-019-01302-4

Porter, M. E., & Heppelmann, J. E. (2014). How smart, connected products are transforming competition. *Harvard Business Review*, *92*(11), 64–88.

Redish, J. (2010). Technical communication and usability: Intertwined strands and mutual influences. *Ieee Transactions on Professional Communication*, *53*(3), 191–201. doi:10.1109/tpc.2010.2052861

Redish, J., & Barnum, C. (2011). Overlap, influence, intertwining: The interplay of UX and technical communication. *Journal of Usability Studies*, *6*(3), 90–101. doi:10.1109/tpc.2010.2052861

Rubin, J. (1994). *Handbook of usability testing*. New York: Wiley.

Saizmaa, T., & Kim, H. -C. (2008, September). A holistic understanding of HCI perspectives on smart home. In *Fourth International Conference on Networked Computing and Advanced Information Management* (pp. 59–65). Gyeongju, Korea: IEEE. doi:10.1109/ncm.2008.141

Savage, G. J. (2003). Introduction: Toward professional status in technical communication. In T. Kynell-Hunt & G. J. Savage (Eds.), *Power and legitimacy in technical communication, Vol. I: The historical and contemporary struggle for professional status* (pp. 1–12). Amityville, NY: Baywood Publishing Compnay. doi:10.2190/pl1

Schneider, S. (2005). Usable pedagogies: Usability, rhetoric, and sociocultural pedagogy in the technical writing classroom. *Technical Communication Quarterly*, *14*(4), 447–467. doi:10.1207/s15427625tcq1404_4

Shank, D. B., Wright, D., Lulham, R., & Thurgood, C. (2021). Knowledge, perceived benefits, adoption, and use of smart home products. *International Journal of Human–Computer Interaction*, *37*(10), 922–937. doi:10.1080/10447318.2020.1857135

Shank, D. B., Wright, D., Nasrin, S., & White, M. (2022). Discontinuance and restricted acceptance to reduce worry after unwanted incidents with smart home technology. *International Journal of Human–Computer Interaction*, 1–14. doi:10.1080/10447318.2022.2085406

Still, B., & Albers, M. (2010). Editorial: Technical communication and usability studies. *Ieee Transactions on Professional Communication*, *53*(3), 189–190. doi:10.1109/TPC.2010.2052860

Summers, S., & Watt, A. (2015, July). Quick and dirty usability testing in the technical communication classroom. In *Proceedings of the 2015 IEEE International Professional Communication Conference (IPCC)* (pp. 1–4). Limerick, Ireland: IEEE. doi:10.1109/ipcc.2015.7235831

Takahashi, D. (2017). PwC: 81% of consumers are aware of smart homes, but only 26% want one. Retrieved from https://venturebeat.com/business/81-of-consumers-are-aware-of-smart-homes-but-only-26-want-one/

Tham, J. C. K. (2018). Interactivity in an age of immersive media: Seven dimensions for wearable technology, internet of things, and technical communication. *Technical Communication*, *65*(1), 46–65.

Usability testing n.d. Usability.gov. Retrieved from https://www.usability.gov/how-to-and-tools/methods/usability-testing.html

Verhulsdonck, G., Melton, J., & Shah, V. (2019). Disconnecting to connect: Developing postconnectivist tactics for mobile and networked technical communication. *Technical Communication Quarterly*, *28*(2), 152–164. doi:10.1080/10572252.2019.1588377

Wright, D., & Shank, D. B. (2019). Technology diffusion and smart living: A living laboratory approach. *Journal of Technical Writing and Communication*, *50*(1), 56–90. doi:10.1177/0047281619847205

Wright, D., Shank, D. B., & Yarbrough, T. (2022). Outcomes of training in smart home technology adoption: A living laboratory study. *Communication Design Quarterly Review*, *9*(3), 14–26. doi:10.1145/3468859.3468861

Zhou, Q. (2014). "That usability course": What technical communication programs get wrong about usability and how to fix it. *Communication Design Quarterly*, *2*(3), 25–27. doi:10.1145/2644448.2644454

Appendix

Appendix A

Sample moderator checklist/script

Pre-test

(1) Be sure that both cell phones and Nest hub are powered on.
(2) Ask participant to read and/or sign consent form. If refused, terminate testing.
(3) Check the status of the door lock. If it is locked, unlock it.
(4) Make sure lamps are off (through the hub).
(5) Return Nest Hub to opening screen (swipe from left).
(6) Check to see that weather information is being displayed on the Nest Hub main screen. Add if not (use Home Control – Photo Frame for this).
(7) Load SD card into camera with power off. Then power on camera. (Cards are located in camera carry bag on the shelf behind the couch).
(8) Check that all devices are plugged in and have power.
(9) Ask participant which type of cell phone they prefer.
(10) Begin phone recording.
(11) Read the following: "To begin, I'd like you to fill out this short questionnaire so that we have some background information about you."
(12) Conduct Pre-test questionnaire.
(13) Begin test.

During test

(1) Read the introduction script.
(2) Begin scenarios and tasks.
(3) Continue to encourage thinking aloud during the test.
(4) Offer assistance only if the test reaches a standstill or participant asks questions.

After test

(1) Read the following: "Thanks for the excellent feedback during those tasks. Now I'd like to conduct a posttest questionnaire. This is the last thing we will ask you to do. Please answer these questions honestly and don't be afraid to criticize the equipment or the test. We want to know your honest opinions."
(2) Administer the posttest questionnaire.
(3) Stop phone and video recordings.
(4) Place pre and posttest-questionnaires in file folder.
(5) Remove SD card from camera and transfer recording to computer folder DESKTOP/RECORDINGS/CAMERA (use USB adapter for SD card). Be sure date and subject name are included in the file name.
(6) Plug phone used for test into computer USB and transfer screen recording to DESKTOP/RECORDINGS/PHONE. Be sure date and subject name are included in the file name.
(7) Unlock the door using hub.
(8) Return weather to Nest Hub Home Screen if necessary (Task 7 is to remove it).
(9) Turn off lamps after returning to original color (through hub).
(10) Press "Home" on TV remote to stop Netflix if still running.
(11) Delete routines "Movie Time" and "Wakeup."
(12) Clear alarm from Hub.
(13) Turn off TV.
(14) Clean area for next test if needed.

Appendix B

Sample Scenario/Task list

Scenario 1

We have simulated a living room that approximates one you might set up with your own smart home devices. The following devices are installed in this room.

- Smart TV
- Next Hub Max
- Lutron Outlet Light Dimmers
- Nest Hello Doorbell
- Nest Smart Door Lock
- Nest Smart Thermostat
- Nest Indoor Security Camera

Tasks

(1) Please attempt to identify each of these devices by pointing them out.
(2) Please briefly explain what you think each of these devices might be capable of doing.

Scenario 2

Next, we'd like for you to access the devices in the room and perform specific tasks. There are three different methods for manipulating the equipment: The Nest Hub, the Google Home cell phone app, and voice commands. For some tasks we will ask you to use specific methods. For others, you may choose your own method. To use voice commands you will need to say, "Hey Google" first – than state your request.

Tasks

(1) Start Netflix on the television.
(2) Play music through the television.
(3) Change the volume of the television.
(4) Alter the home display of the Nest Hub by removing the weather information.
(5) Using the Nest Hub, set an alarm for five minutes from now.
(6) Use the Nest Hub to translate the phrase, "Hello, would you like some coffee?" into Spanish.
(7) Turn on the front lamp.
(8) Turn on the table lamp.
(9) Set front lamp to 75% brightness and back lamp to 85%.
(10) Turn the front lamp green and the table lamp orange.
(11) Set lamps to turn off in five minutes.
(12) Access live video from the doorbell.
(13) Speak through the doorbell.
(14) Lock the door.
(15) Access the video feed from the indoor security camera.
(16) Alter the current temperature of the thermostat.

Scenario 3

Next, we'd like for you work with what are called "routines." Routines allow you to program several devices together, so that specific things happen with each of them in response to a single command.

Tasks

(1) Create a new routine and name it "Wakeup."
(2) Edit the "Wakeup" routine to make it:

- Activate when you say "Hey, Google, I'm awake."
- Turn lamps to 50% brightness with purple color.
- Change thermostat to 72 degrees.
- Read the local weather forecast.
- Read any calendar appointments for the day.
- Tell you if your phone battery is low.
- Play the news.

(3) Create a new routine called "Movie Time."
(4) Edit the movie time routine to make it:
- Have Nest Hub say, "Let's Watch a Movie" when launched.
- Lock the door
- Adjust the thermostat to 68 degrees
- Adjust both lamp colors to green (must add manually)
- Turn on the TV (must add manually)
- Start Netflix (must add manually)

Appendix C

Sample Post-Test Questionnaire

Post-Test Questionnaire

Name____________________________Date__________________________

	Question	N/A	Strongly Disagree			Strongly Agree	
			1	**2**	**3**	**4**	**5**
1	I found it easy to connect to the devices used in this study using the Google Home cell phone app.						
2	I found it easy to connect to devices using the Nest Hub.						
3	I found it easy to control devices using the Google Home cell phone app.						
4	I found it easy to control devices using the Nest Hub.						
5	I found it easy to link multiple devices in routines.						
6	I have a better opinion of smart home devices than I did before this study.						
7	I believe it would take a long time for me to learn to use this technology.						

General questions

(1) What was the most frustrating thing about using this equipment today?
(2) What was the most pleasant surprise you encountered?
(3) What suggestions would you have for improving the Google Home App?
(4) What suggestions would you have for improving the devices?
(5) What suggestions would you have for improving the Nest Hub?