

# **z-Tree in VLab: A Method for Running Online Economic Experiments**

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## **Abstract**

We propose a convenient method to run online economic experiments via z-Tree, should a virtual lab with a file server exist. Assuming these technologies are already available in many universities, this method does not require any additional tool or resource. Once the setup is completed, a researcher can run any type of experiment (including interactive tasks) with subjects participating in real time. With the virtual lab architecture, a researcher finds the very same desktop she has in a physical lab; therefore, she does not need to adapt to any different platform. The researcher only needs additional software to communicate with the subjects (e.g., Zoom), but this is probably not a burden since most have already adapted to these applications during the COVID-19 pandemic. We believe that the use of z-Tree through a virtual lab, necessitated by the current lack of access to physical subjects, will continue to provide a convenient method for running online experiments with z-Tree during the pandemic as well as beyond.

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**Keywords:** Online experiments, laboratory experiments, z-Tree, virtualization, virtual lab.

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## 1. Introduction

The COVID-19 pandemic has affected the world enormously, killing more than a million people, driving thousands of firms out of business, and leaving millions unemployed. Although researchers are probably not in the front line of people who have been directly affected, those working in experimental fields have likely faced more disruption in their research. The main obstacle the pandemic has brought for experimental economists is the technological difficulty of running online experiments using the programming framework they have been accustomed to in a physical lab. This paper primarily addresses this concern, mainly for the users of z-Tree, which is one of the major programming tools used by experimental economists (Fischbacher 2007). In addition to putting forward the virtual setup of z-Tree, we present our own experience (at Koc University) about recruitment and registration for online experiments and address relevant issues such as collecting consent forms in the physical absence of subjects and managing session quotas; essentially for guiding researchers who may not have access to a dedicated recruitment platform such as ORSEE (Greiner 2015).

Economic experiments are usually conducted via a software tool, which allows the experimenter to program each possible scenario, demonstrates to subjects the corresponding screens and securely collects data. For the last two decades, z-Tree has been the dominant tool in the field of experimental economics, although there are other reliable means such as oTree (Chen et al. 2016).<sup>1</sup> Traditionally, z-Tree is installed and used in closed-circuit experimental labs. These are physical locations, where a set of physical computer terminals are connected to each other by a network but isolated from the rest of the world. This approach is fine if participants can visit that specific location. However, when there are obstacles to bringing subjects to a lab, as in the COVID-19 outbreak, a potential solution could be to deliver the lab to the subjects. In this paper, we describe how to achieve this through a virtual computer lab (VCL or VLab), which is based on the technology called *virtualization*, and more specifically *desktop virtualization*.

Virtualization of physical resources as a broad term dates back to the 1960s. However, *desktop virtualization* or *virtual desktop infrastructure* is a technology of the last two decades. Some universities have been using this technology for some years, to switch from physical labs to virtual labs (e.g., North Carolina State University's VCL has been available since 2004). However, a big fraction accelerated this process after the COVID-19 outbreak to strengthen their online teaching capacities. The major advantages of virtual labs are 1) they are cost-effective since they usually decrease operational costs (e.g., hardware, staff, space, licensing, etc.), 2) they increase end-user satisfaction since they are reachable from anywhere in the world.

In the next section, we present a basic explanation of a VLab architecture; however, our aim is not to guide the readers on how to set up one, because depending on available resources (e.g., virtualization software, hardware, etc.) there are many ways of doing it and it is a task which is

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<sup>1</sup> z-Tree (Fischbacher 2007) has more than ten thousand citations in Google Scholar as of the time of this draft, which can be a proxy for how widely it has been adopted by experimental economists around the world.

best undertaken by IT experts.<sup>2</sup> We rather target researchers as an audience, whose universities/institutions already have virtual labs, but who are not aware that they can actually utilize this environment to run online economic experiments via z-Tree. A simple internet search reveals that most of the universities around the world have virtual labs. We therefore predict that many experimental researchers will be able to benefit from the solution we present. The infrastructure of virtual labs might vary among universities, however the methodology we present here, or slightly modified versions of it can still be used in many of the cases.<sup>3</sup> The main components of our method are as follows:

- 1- ***Virtual Computer Lab***: This enables the members of an institution (e.g., students, faculty, staff, etc.) to virtually reach the desktop of a lab computer from their own devices (e.g., PCs, laptops, tablets, etc.) via a client software (e.g., VMware Horizon Client, Remote Desktop, etc.) or a web browser (e.g., Chrome, Firefox, Opera, etc.). It is built using VMware Horizon at the university of the authors; however, one may encounter a virtual lab implemented with another commercial or freeware virtualization solution by various vendors (e.g., Citrix, Amazon, Microsoft, Apporto, etc.).
- 2- ***File Server and File System***: A file server is simply a network, which enables specified users to reach folders and files in a shared storage space. This is a very common technology used in company/university networks. A file system, on the other hand, sets the rules of data storage in terms of structure and logic. The file server and the file system used in this example are Micro Focus OES and NSS, respectively. This layer is important in terms of installing z-Tree and defining permission rules of different users on the z-Tree folder.
- 3- ***Communication Software***: Since the experimenter and the subjects are all in different locations, a tool to virtually connect them is required. The choice of the authors is Zoom; however, an alternative application can handle this task, too (e.g., Microsoft Teams, Skype, Cisco Webex, etc.).
- 4- ***Registration Platform***: We use Google Forms for registration, the step where we also collect the electronically confirmed consent forms. However, alternatives like Doodle can be used by other researchers. Users of ORSEE or similar platforms may neglect this layer since they already have a dedicated setup for recruitment and registration.

The literature on virtual labs generally comes from computer science, and particularly focuses on providing online environments for hands-on activities in information security, computer networks, etc. (Keller and Naues 2006; Konak et al. 2014; Gercek et al. 2016; Kabiri and Wannous 2017). However, we are not aware of any research proposing the utilization of virtual labs to run online economic experiments. Related to the current paper, in a recent study, Duch et al. (2020)

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<sup>2</sup> Virtual home-labs are also possible to set up at feasible prices with freeware virtualization software and cloud-based solutions (or if the necessary hardware is available). However, we leave this case out of the scope of this paper since it requires some technical background.

<sup>3</sup> This paper is based on our experience at Koc University, so the methodology presented here is based on some assumptions mostly related to the choice of technological resources made available by the institution. The readers are encouraged to adapt the solution we present to their case, depending on the resources available to them.

propose a method (called *z-Tree unleashed*), which also employs virtualization to run *z-Tree* over the internet. To our knowledge, this is the only paper which offers a feasible way to use *z-Tree* over the internet, hence it has gained considerable attention from the *z-Tree* community. In their method the authors provide a virtual machine image (to be imported into Oracle VM VirtualBox), which integrates all necessary scripts. However, this solution requires a set of configurations including installation of a (globally reachable) thin server, which we anticipate may not be trivial tasks for many economists.<sup>4</sup> We, on the other hand, do not provide any tools or scripts, but propose an easy alternative method to run remote economic experiments with *z-Tree*, should a VLab infrastructure and a file server be available. We hope that the current method will be useful in transferring already-designed *z-Tree* experiments to a remote setup, as well as running new experiments, through the pandemic and beyond, given that online experiments may have their advantages in terms of efficiency, for subjects and researchers alike. Finally, besides presenting a solution for the technological issue of running online experiments with *z-Tree*, the current paper also includes suggestions on how to handle the recruitment for an online experimental project, which can be of help to researchers who have not had the experience before.<sup>5</sup>

The rest of the paper is structured as follows. Section 2 presents a basic explanation of the virtualization concept and shares the architecture of the VLab at Koc University as an example. Section 3 explains how *z-Tree* should be installed on a file server and which configurations are necessary. Section 4 reviews important steps to complete before running an experiment. Section 5 explains how a session should be conducted, lists undesirable issues which may be encountered during a session and presents ways to overcome them. Section 6 summarizes the key points to be completed after a session. Section 7 concludes.

## 2. The Basics of a Virtual Lab

Traditionally, computer labs are locations where a group of computers are connected to each other by a network. However, especially in the last decade this understanding has been changing and physical labs are getting replaced by virtual labs. This change has been possible due to a technological advancement called *virtualization*, which can be simply defined as dividing any computer resource (e.g., server, desktop, storage, operating system, etc.) into several virtual ones. Virtualization is a phenomenon which has existed for more than half a century; however, virtual labs have become possible only with a specific application of it: *desktop virtualization*. This technology (also known as *virtual desktop infrastructure*) is basically the process of creating virtual desktop environments hosted by a central physical server and delivering them to end-users through a network. Virtualization requires a *hypervisor* (or *virtual machine monitor*) which enables a physical server to host several independent virtual machines by allocating its resources to each, in line with their requirements. There are mainly two types of hypervisors. While Type 1 (or *bare*

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<sup>4</sup> After installation and initialization, each client is assigned a Linux account, and both *z-Tree* and *z-Leaves* run on a single computer (*zTu* server). Then a virtual display for each user is captured by VNC and streamed from the *zTu* server to users (who use web browsers) via the thin server, and vice versa.

<sup>5</sup> One related study in this regard is Zhao et al. (2020), where the steps of running online experiments at the University of California, Santa Cruz is summarized. However, they assume *oTree* to be the experimental software.

*metal*) hypervisors run directly on a physical server, Type 2 (or *hosted*) hypervisors run on an operating system owned by a server.

Deploying a VDI environment has many steps such as selecting the most convenient hardware (for servers) and the right hypervisor, and handling user management, connection security and data security, etc. Luckily, there are commercial packages available, which enable IT administrators to manage all the relevant tasks on a single platform and form a virtual lab in a short amount of time. We predict that many of the readers will have some sort of virtual lab already in place at their institutions.

Some major virtualization platforms are VMware Horizon, Citrix Virtual Apps and Desktops, Amazon WorkSpaces, Windows Virtual Desktop, Nutanix Xi Frame, etc. Therefore, it is quite likely to encounter a virtual lab built with any of these, or even an unmentioned virtualization solution. We have no reason to prefer or promote one over others among any of these platforms; however, to provide a basic understanding of the setup, we share several key points about the one utilized in our experience, *VMware Horizon*.

VMware Horizon is a desktop and app virtualization product; however, readers may disregard the app virtualization scope and only consider the desktop virtualization service. This product has different components which together enable an organization to deliver desktops (and applications) from centralized servers to end-users (See Figure 1 for the architecture). The vendor prefers to divide these components into three different subgroups as *core components*, *underlying infrastructure components*, and *enhancing components* (See Table 1 for the list of components).

While explaining all components may be unnecessary for the scope of this paper, we would like to mention a few notable components.<sup>6</sup> VMware Horizon Client (either installed or using HTML access) enables end-users to reach virtual desktop pools from their own devices (e.g., PCs, laptops, tablets, etc.). Horizon Connection Server is the tool which authenticates users (usually via Active Directory) and transmits their requests. When these requests come from the outside, VMware Unified Access Gateway provides users with a secure tunnel which bypasses the corporate/institutional firewall. Horizon Agent is the communicator between virtual desktops (or RDSH servers if published applications are used) and the Horizon Client. VMware Dynamic Environment Manager handles profile and policy management for Windows desktops. While VMware vSphere is the platform where virtual desktops (and applications) run, VMware ESXi is the hypervisor which runs directly on the hardware (i.e., Type-1). VMware vCenter, on the other hand, is the console to manage all the underlying components.

Finally, we need to mention a few key terms or technologies related to the topic. *Master image* (also known as *golden image*) - usually consisting of an operating system, hardware configuration and applications - forms a template for the virtual desktop. Thanks to this technology, IT administrators can deploy numerous identical virtual desktops cloned from it. With this technology, a virtual lab can provide for users several virtual desktop options with different operating systems (e.g., Windows 7, Windows 10, Linux, etc.). VMware provides two different technologies for cloning; *View Composer Linked Clones* and *VMware Instant Clone Technology*.

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<sup>6</sup> For more details visit <https://techzone.vmware.com/>

While the former is the traditional method of cloning, the latter is a recent technology which enables extremely fast creation and delivery of virtual desktops. With this novel method, a virtual desktop exists only during the session, and is destroyed as soon as the user logs out.

### 3. Installation of z-Tree

Organizations like universities or companies usually provide a file server where (authorized) users can reach shared folders and documents. We assume many universities have similar environments in their networks. As many z-Tree users already know, “*the easiest way to install z-Tree is to put z-Tree and z-Leaf in a common directory on a file server.*” (z-Tree 4.1 Tutorial and Reference Manual, p. 117). Therefore, in our experiments we basically followed the very same approach and placed a folder consisting of *ztree.exe* and *zleaf.exe* on the file server. Additionally, we applied a set of permission rules to take full control of the z-Tree folder on the file server.<sup>7</sup> Initially, we asked the IT department to create a number, N, of dummy accounts (with the most basic capabilities) to be used by the subjects.<sup>8</sup> Then the folder was hidden from all the users in the university, except us (experimenters) and the dummy accounts (subjects). In other words, only we and the users of the dummy accounts could see or reach the z-Tree folder. While we have the whole set of NSS permissions in the folder, the dummy accounts can only see and run two files (*zleaf.exe* and a *batch file*) in the same folder (See Figure 2).<sup>9</sup>

The batch file enables the subjects to start z-Leaf with a common configuration. It is not compulsory, but we recommend the use of a batch file to configure z-Leaf screens in a common way; otherwise, subjects may encounter different font sizes depending on the settings (e.g., screen resolution, scaling, etc.) of their host devices. The following simple code line is the content of our batch file, however the starting configuration of z-Leaf is a matter of experimenter preference, so others may choose different settings.

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start zleaf.exe /language tr /fontsize 20
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In our method, each participant is provided with the credentials of a private dummy account in advance and reaches the virtual lab as that dummy user. When she logs in to VLab, she faces a Windows 7 screen as an independent entity from her own operating system.<sup>10</sup> At this point, the participant is expected to reach the z-Tree folder on the file server and start the batch file to display the z-Leaf screen. This is possible with the right instructions, however unless the folder is on a trivial directory, the best practice is to create a shortcut for the batch file at the start menu.<sup>11</sup> Otherwise, participants might get lost on the file server, leading to a waste of time.

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<sup>7</sup> As noted earlier, we assume NSS as the file system, however readers who encounter other file systems such as NTFS, can find workarounds to apply the same approach.

<sup>8</sup> N should be greater than or equal to the maximum number of subjects who will attend any session.

<sup>9</sup> See Figure 4 for the details of NSS permissions set in the folder. Moreover, Figure 5 shows the dummy accounts can see specific files through file specific additional permissions (i.e., *file scan*).

<sup>10</sup> The operating system of the virtual desktop is set by the IT department through the master image. z-Tree is expected to work just fine with any other version of Windows.

<sup>11</sup> This must be done (by IT staff) over the master image.

Finally, note that we are a small group of experimental economists at Koc University, therefore we can easily communicate and manage the z-Tree folder via our own personal accounts without causing any accidental interference. However, in larger groups, in case of granting administrator permissions to a large group of people, as one runs a session, another might reach the same folder to run some tests. To prevent such problems, a unique admin user can be created and used by researchers in order, should the password be reset each time the account passes to another person. Or simply, independent z-Tree folders can be created on the file server and owned by different researchers through different permission configurations.

#### 4. Pre-Session Activities

The announcement of an experiment is not among the issues affected by the conditions of the pandemic, so this can be done as before. At our institution, we announce sessions through the Daily News & Announcements Bulletin of the university, which is electronically sent to all users. This post shares a link for registration with the potential participants. We manage registrations via Google Forms. This stage is also where we collect the electronically confirmed consent forms, thus it is important to make sure one can only sign in with her private institutional account and cannot register multiple times (See the settings in Figure 3).

When a respondent signs the registration form, the very first page contains the consent form and asks the person whether she accepts it or not. If the person declines, the form automatically skips to an exit page which thanks them for their time.<sup>12</sup> Therefore, the respondent can only proceed to next pages of the form if she confirms her consent. In the second page, there is a Google Drive link for an installation manual on VMware Horizon Client and the respondent is asked if she confirms she will have installed it by the time she attends the session.<sup>13</sup> As in the first page, the respondent can proceed to the next page only if she confirms. The actual point of this page is not to get a promise, but to share the link for the manual and make sure the potential subject knows she is expected to install the client application. Note that, since all respondents are set to automatically get a copy of their responses, the manual is also automatically sent as an attachment to the receipts. Consequently, we make sure everyone who registered has a copy of the installation manual in her inbox and nobody forgets the session she signed up for. Otherwise, the experimenter(s) may get many unnecessary e-mails inquiring about these matters. In the last page of the form, the respondent is asked to enter some basic identifying information and choose the session she wants to attend. This brings us to another issue: *session quota management*. We handle this issue with an add-on called *formRanger* together with a few lines of Microsoft Excel commands in the response sheet.

Once the participant list for a particular session is finalized, those who registered get an e-mail which shares some key reminders about the experiment and the Zoom link for the session,

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<sup>12</sup> This is possible in Google Forms by the following setting: *Go to section based on answer*

<sup>13</sup> As explained in Section 2, VMware Horizon Client can be run without installing the application (i.e., on a web browser), too. Therefore, this step of the registration form should be neglected by the experimenters who permit HTML access.

preferably a day before the session.<sup>14</sup> On the other hand, we configure the Zoom settings such that everyone connects to the session through a waiting room as muted and is unable to chat privately with other participants. For efficiency, it is better to create a meeting template on Zoom and use the same settings for each session.<sup>15</sup>

## 5. During-Session Activities

We start the Zoom meeting for a session 5-10 minutes earlier and take the participants from the waiting room to the meeting room. Until the exact starting time, we send private messages (via Zoom chat) which contain unique dummy account credentials, to everyone who showed up.<sup>16</sup>

After the general instructions are presented on Zoom, we ask participants to connect to the VLab using the account details sent to each.<sup>17</sup> Normally, they can start VMware Horizon Client in two different ways:

- 1- Installed Application
- 2- HTML Access (Web Browser)

Both options have their advantages and drawbacks, and the choice depends on the experimenter's preference. Using web browsers is attractive since it does not require any effort from participants. On the other hand, using the installed application decreases the frequency of connection problems, and consequently increases user satisfaction (See Figure 6 for a visual comparison of the two methods).

In our case, the total duration of a session was quite long (around 1.5 hours), hence we wanted participants to experience the best possible connection performance. Eventually, we required them to install the client application (at any point) before the session. We made this requirement clear both in the registration phase and in reminder messages sent before a session. This choice asks for a pre-session effort from participants; however, we did not experience any problems in recruitment, possibly because we had good average payment and a high participation fee.<sup>18</sup> We

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<sup>14</sup> For the e-mails, it is best practice to use an institutional account name (e.g., experiments@ku.edu.tr) rather than a personal one and formal e-mail templates to reduce the interaction between subjects and experimenter.

<sup>15</sup> In case you have small surveys, which are not main parts of the experiment but just test sample's general understanding of instructions, you may use Zoom Polls and insert them into the meeting template, too.

<sup>16</sup> Note that a participant's decisions or responses in a session cannot be traced through the dummy account credentials assigned to her, because the VLab assigns random computer names (e.g., KUGPU-###) for each login incident independent of the username and z-Tree keeps only these random computer names as client identifiers.

<sup>17</sup> Written instructions can be shared with the participants through a Google Drive link. However, if the experimenter needs to present the instructions as in a lecture, sharing pre-recorded presentations (i.e., videos) might be more efficient. We prepared instructions in the form of videos via Microsoft PowerPoint and shared them on Zoom (i.e., screen share). Our perception is that participants grasp the instructions much better when they are shared in a professional video format.

<sup>18</sup> This installation task requires no more than 5 minutes, should a clear manual be provided by the experimenter.



also got very few e-mails inquiring about experienced installation issues. Furthermore, there were only three participants (out of 234 as of this draft) who reported that s/he had forgotten to install the software before the session. Since we asked about this at the beginning of each session, we could quickly detect and exclude them from the session by paying the participation fee. As a result, we believe that using a client software does not impose much cost. However, HTML access, without any software installation should be feasible in many contexts, as well.

Once participants are logged in to VLab, they are told to start z-Leaf (preferably via the batch file). Of course, the experimenter must have already logged in and started z-Tree. The experimenter should control via the *Clients Table* whether everyone has started z-Leaf or not. As soon as the number of connected clients is equal to the number of participants in Zoom, the treatment can be started. The management of the experiment is pretty much like it is in a physical lab. If everything goes smoothly, the experimenter does not need to intervene, and the session is concluded with the production of output files. Once the experimenter confirms the existence of output files (more specifically the payment file) in the folder, she can tell the participants to log out from VLab and thank them for their time. However, although this is rare, problems can occur just as in physical labs. From here on, we discuss three types of problems we have encountered in the virtual use of z-Tree and propose solutions for them.

Windows Lock Screen: A problem participants may encounter is the activation of the lock screen, while they are inactive on z-Leaf and consequently on the virtual desktop. Those who run non-stop treatments should have no such concern, since participants will be active on the virtual desktop during the whole session. However, if one runs a session where between treatments subjects are expected to return to the communication tool (on the host machine) and listen to the new instructions, this issue might be relevant. According to our experience, around 5-10% of participants experienced such a problem when they returned to the inactive virtual desktop. Since most of the participants did not experience this problem, it is clearly not related with the master image configurations. When we kept track of those experiencing the problem, we figured out that it is related with the version of VMware Horizon Client. Although we considered recommending a specific version to be installed, we later decided not to put an additional criterion to the pre-session tasks. Instead, we chose to include a small tip in the instructions about how to solve this problem should a participant experience it. Clearly, a user experiencing this issue just needs to unlock the screen (Ctrl+Alt+Delete) and enter her credentials. However, the tricky part is that pressing this key combination on the physical keyboard runs this command on the host machine. Therefore, the user should run this command on the virtual desktop via a button on the VMware Horizon Client's toolbar.<sup>19</sup> Then, she can return to the Windows session on the virtual desktop and find z-Leaf as she left. Rarely, some participants have trouble with their keyboards while trying to write something on the virtual desktop (e.g., entering credentials to unlock the screen). In such cases the experimenter should guide them to the *On-Screen Keyboard*. Therefore, the experimenter is expected to know how to reach it in advance. This application is normally located in "Windows\System32" directory, but in most cases a shortcut exists in the Start menu. However, if

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<sup>19</sup> The same button (*Send Ctrl-Alt-Delete*) is available with HTML access, too.

it is necessary for unlocking the screen (i.e., the Start menu is inaccessible), then it can be reached through the *Ease of Access* button which is usually located at the bottom of the lock screen.

Disconnection from the VLab: This problem usually happens due to internet connection problems coming from the participant's side. Therefore, the participant needs to reconnect to the VLab. The good news is that unless the subject logs off, the corresponding virtual desktop keeps working on the server for a reasonable amount of time; only the participant stops monitoring it due to the connection problem.<sup>20</sup> Therefore, as soon as the participant reconnects to the VLab, she finds everything just like she left, that is, she can continue the experiment exactly from where she was before. Here, one useful tip is to tell the participants not to shut down the Horizon Client (application or web browser) under any circumstance, because unless the connection problem takes longer than a threshold amount of time, the connection between the host machine and the VLab is automatically recovered and the participant can continue the experiment without any extra effort to reconnect.<sup>21</sup> However, if this threshold is met, or due to any other issue, the Horizon Client may automatically shut down. In this case, after the connection problem is solved, there is nothing else than restarting the Horizon Client and reconnect to the VLab with the provided account credentials. However, as mentioned above, the subject will still be able to find the screen as she left, since she did not log off. Apart from the time loss, the only drawback of this scenario is the compatibility issue with screen resolutions (See Figure 7).

In the physical lab environment, every participant uses a unique kind of device in terms of hardware and software configuration. However, when it comes to the VLab setting, each participant uses her own device, which means we are facing various configurations, more specifically, devices with different screen resolutions and scaling. Normally, using a client software and a batch file enables everyone to monitor z-Leaf in a common way, but when the VLab connection must be renewed, some participants find the z-Leaf not fitting the screen anymore. In other words, the corresponding z-Leaf has an over scaling problem, likely because z-Tree does not support auto-scaling. Luckily, there is a simple way of solving this problem, by closing the z-Leaf window and restarting it (preferably through the batch file).<sup>22</sup> When z-Leaf is restarted, it scales correctly and replaces the closed z-Leaf, so that the participant can continue the experiment from the same state she would have been in.

Crash of z-Leaf: Compared to the other problems, this issue happens quite rarely. As we mentioned before, when the subject disconnects only from the VLab, this does not affect the connection between z-Tree and z-Leaf since the virtual desktop keeps working on the server.

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<sup>20</sup> In the VLab setting of Koc University, virtual desktops keep working for twenty minutes in case of disconnection. Hence, the user can reach the very same virtual desktop and her work if she reconnects in this time. Otherwise, the virtual desktop is automatically deleted.

<sup>21</sup> This threshold is around 2 minutes in our setting.

<sup>22</sup> For participants, closing the z-Leaf window is also tricky, since it covers the whole screen by default and has no simple "close" button. The easiest way is to press *Windows* button on the keyboard (or *command* in MacOS) to activate the Start button of the virtual desktop and close by a command over the z-Leaf symbol on the taskbar. Alternatively, by sending "Ctrl+Alt+Delete" on the virtual desktop, *Windows Task Manager* is started, and z-Leaf is closed over the *Applications* tab.

However, on rare occasions subjects have reported that their z-Leaves crashed while they were still connected to the VLab or they found their z-Leaves shut down when they returned to the VLab after a connection problem.<sup>23</sup> In such cases, the participant is told to restart z-Leaf, however she may find the welcome page of z-Leaf instead of where she was before the crash. If so, the experimenter should solve the problem through the Clients Table. Most probably, while the former z-Leaf is shown “disconnected”, the new one will be at the end of the table as “idle”. Then, the experimenter should select the new/idle client and move it over the row of the former/disconnected client, as suggested in the z-Tree manual.

## 6. Post-Session Activities

Once a session is completed and subjects left the session, the first thing to do is to save output files. One way is to copy these files from the original folder on the file server and paste to a personal folder on the host computer. This is possible if the necessary permission about disk sharing is given in the first connection to the VLab from a particular device.<sup>24</sup> Another way is to use a USB flash drive to take copies of output files from the original location.<sup>25</sup> Other alternatives are using cloud drives such as Microsoft OneDrive and Google Drive.

Afterwards, passwords shared with the participants need to be reset for security concerns. Organizations have web pages for individual password operations; however, it may be quite inefficient to use this method when there are many accounts. Therefore, the best practice is to contact the IT department and ask for help. Usually, IT departments handle this kind of operations by automatic tools extremely fast.

## 7. Conclusion

Social distancing measures due to the COVID-19 pandemic have prevented experimental economists from running economic experiments in physical computer labs. Although there are a few existing platforms to run online experiments or surveys, such as Amazon MTurk, Prolific, and Qualtrics, many of them lack the capabilities to run interactive tasks in real time. *z-Tree unleashed*, proposed by Duch et al. (2020) provides a novel solution for running z-Tree over the internet, and has received well-deserved appreciation from the community of experimental economists. Nevertheless, this might not be the most efficient solution for some, since it requires several involved tasks at the setup phase, such as the installation and configuration of a thin server. Therefore, we propose an alternative and convenient method for those who would like to use z-Tree over the internet and have access to a virtual lab with a file server at their institution.

As in physical lab conditions, some problems might occur in the virtual lab setting; however, they are not unsolvable. Between September and December 2020, we have conducted 20+ sessions

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<sup>23</sup> The second case probably means the former virtual desktop is somehow deleted and a new virtual desktop is created for the same user.

<sup>24</sup> See Figure 8 for the corresponding question.

<sup>25</sup> Figure 9 shows the option on the client application’s toolbar to connect a USB flash drive to the virtual desktop and how the local hard disk drive is located (mapped as “Network Drive (Z:)”) among the other networks.

via the virtual lab at Koc University and managed to complete all of them with success. Among the 234 subjects who participated in the sessions through VLab, only two were unable to finish the experiment, but even this did not prevent us from completing the relevant sessions as planned.<sup>26</sup>

To conclude, we believe that the method proposed in this paper can help many experimental economists who are used to programming experiments with z-Tree run their experiments online, even after the restrictions of the pandemic are relaxed. We ourselves plan to keep running laboratory experiments in this platform unless the design enforces a physical lab environment, because our experience has been that online experiments provide many advantages for both subjects and the experimenter.<sup>27</sup>

## References

- Chen, D. L., Schonger, M., & Wickens, C. (2016). oTree—An open-source platform for laboratory, online, and field experiments. *Journal of Behavioral and Experimental Finance*, 9, 88-97.
- Duch, M., Grossmann, M. R., & Lauer, T. (2020). z-Tree unleashed: A novel client-integrating architecture for conducting z-Tree experiments over the Internet. *Journal of Behavioral and Experimental Finance*, 28, December 2020, Article 100400.
- Fischbacher, U. (2007). z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental economics*, 10(2), 171-178.
- Fischbacher, U., Bendrick, K. & Schmid, S., (2019). z-Tree 4.1 Tutorial and Reference Manual Available at University of Zurich: [https://www.ztree.uzh.ch/static/doc/manual\\_v4.pdf](https://www.ztree.uzh.ch/static/doc/manual_v4.pdf)
- Gercek, G., Saleem, N., & Steel, D. (2016). Implementing cloud based virtual computer network labs for online education: Experiences from a phased approach. *International Journal of Online and Biomedical Engineering (iJOE)*, 12(03), 70-76.
- Greiner, B. (2015). Subject pool recruitment procedures: organizing experiments with ORSEE. *Journal of the Economic Science Association*, 1(1), 114-125.
- Kabiri, M. N., & Wannous, M. (2017, July). An experimental evaluation of a cloud-based virtual computer laboratory using openstack. In *2017 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)* (pp. 667-672). IEEE.

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<sup>26</sup> These two participants' issues were not unsolvable, however they had difficulty in following our guidance and showed reluctance to continue the experiment. We therefore let them leave. Normally, this would create a problem since z-Tree asks for the same number of participants in all treatments of a session. However, in our experiment, which is based on an individual decision-making task, we solved this issue by logging into the VLab with their assigned accounts and completing the tasks from the stages they left, for the sake of completing the sessions successfully. We dropped their data from the output, naturally.

<sup>27</sup> Out of 232 subjects who completed the experiment under the proposed setting; 226 gave a positive answer to the following survey question: "Would you like to participate in further experiments?" We think this high rate of positive answers reflects that participants are quite comfortable and content with the online experimental setting.

Keller, J., & Naues, R. (2006, December). A collaborative virtual computer security lab. In *2006 Second IEEE International Conference on e-Science and Grid Computing (e-Science'06)* (pp. 126-126). IEEE.

Konak, A., Clark, T. K., & Nasereddin, M. (2014). Using Kolb's Experiential Learning Cycle to improve student learning in virtual computer laboratories. *Computers & Education*, 72, 11-22.

Zhao, S., Lopez Vargas, K., Friedman, D. & Gutierrez Chavez, M.A. (2020). UCSC LEEPS Lab Protocol for Online Economics Experiments (May 6, 2020). Available at SSRN: <https://ssrn.com/abstract=3594027>

**Tables**

*Table 1: Components of VMware Horizon 7*

Core	Underlying	Enhancing
Horizon Administrator, Horizon Console, Horizon Connection Server, Horizon Agent, VMware Horizon Client	VMware vSphere Foundation for Horizon, VMware vCenter Server, VMware ESXi	VMware Unified Access Gateway, VMware App Volumes, VMware Dynamic Environment Manager, VMware Workspace ONE Access

**Figures**

*Figure 1: Logical architecture of VLab (VMware Horizon 7)*

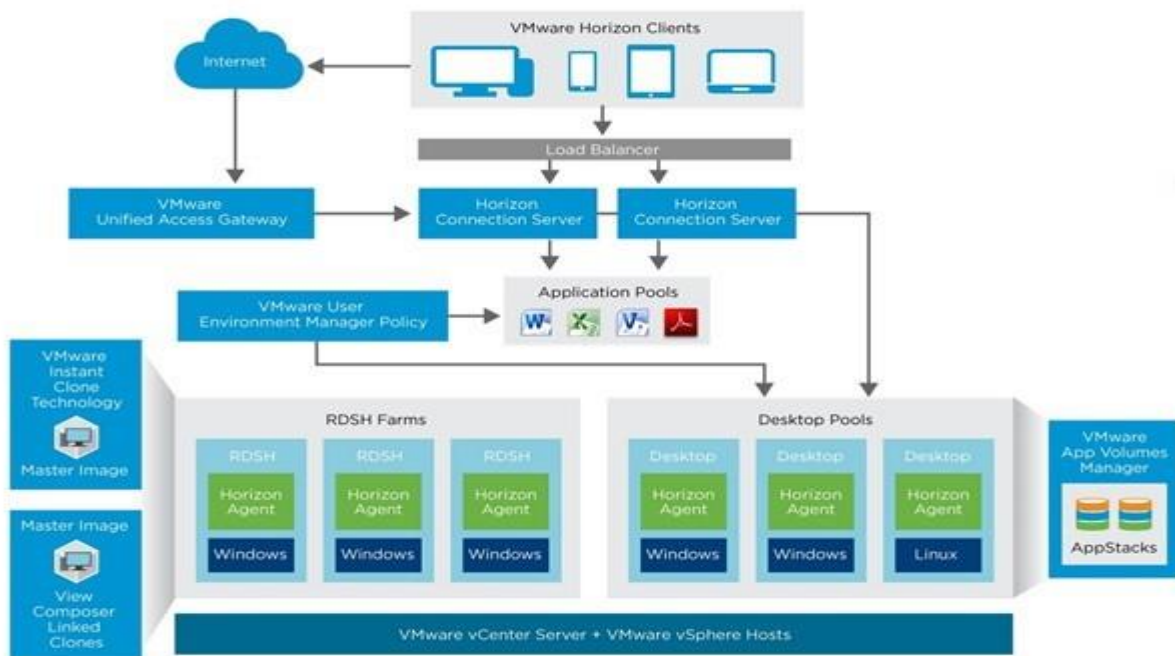


Figure 2: View of the z-Tree folder from the perspectives of different users (experimenter vs. participant)

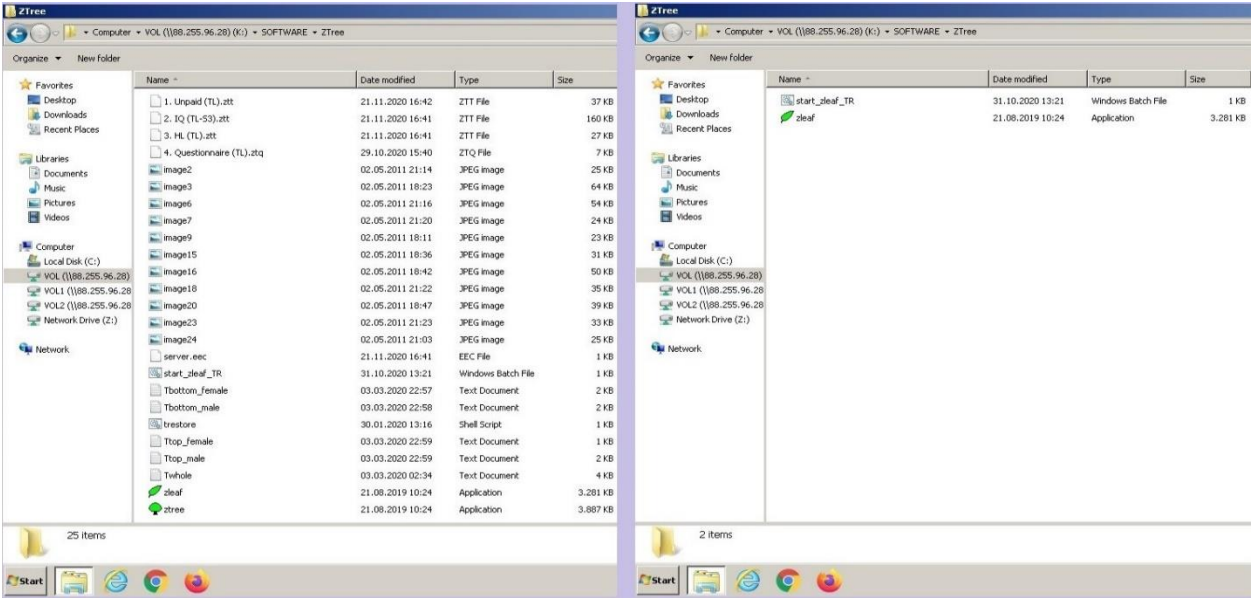


Figure 3: Google Forms settings for registration phase

### Settings

General      Presentation      Quizzes

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Collect email addresses

Response receipts ?

If respondent requests it

Always

Requires sign in:

Restrict to users in Koc University and its trusted organizations ?

Limit to 1 response  
Respondents will be required to sign in to Google.

Figure 4: NSS permissions granted to different users (experimenter vs. participant)

```

K:\SOFTWARE\ZTree\trestore.sh - Notepad++ [Administrator]
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
trestore.sh
1 #!/bin/bash
2 # Restore rights to volume ZTree
3 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r sa irf
4 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rwcefm trustee ".CN=SERTAC.OU=USR.O=KU.T=LOGINTREE"
5
6 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rwcefm trustee ".CN=EKOTAN16.OU=STD.O=KU.T=LOGINTREE"
7
8 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf01.OU=OTHER.O=KU.T=LOGINTREE"
9
10 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf02.OU=OTHER.O=KU.T=LOGINTREE"
11
12 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf03.OU=OTHER.O=KU.T=LOGINTREE"
13
14 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf04.OU=OTHER.O=KU.T=LOGINTREE"
15
16 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf05.OU=OTHER.O=KU.T=LOGINTREE"
17
18 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf06.OU=OTHER.O=KU.T=LOGINTREE"
19
20 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf07.OU=OTHER.O=KU.T=LOGINTREE"
21
22 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf08.OU=OTHER.O=KU.T=LOGINTREE"
23
24 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf09.OU=OTHER.O=KU.T=LOGINTREE"
25
26 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf10.OU=OTHER.O=KU.T=LOGINTREE"
27
28 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf11.OU=OTHER.O=KU.T=LOGINTREE"
29
30 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf12.OU=OTHER.O=KU.T=LOGINTREE"
31
32 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf13.OU=OTHER.O=KU.T=LOGINTREE"
33
34 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf14.OU=OTHER.O=KU.T=LOGINTREE"
35
36 rights -f "/media/nss/VOL/SOFTWARE/ZTree/" -r rc trustee ".CN=DNY-zleaf15.OU=OTHER.O=KU.T=LOGINTREE"

```

Explanation of NSS permissions are as follows: (r)ead, (w)rite, (c)reate, (e)rase, (f)ile scan, (m)odify

Figure 5: File specific NSS permissions to show the batch file to the participants

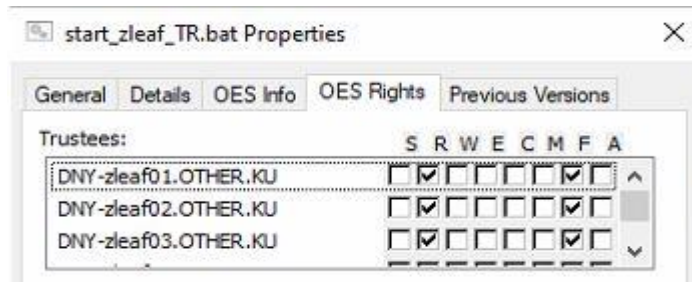


Figure 6: A sample session where two participants connect via different tools (installed application vs. Google Chrome) as the experimenter manages the session via another type of web browser (Opera)

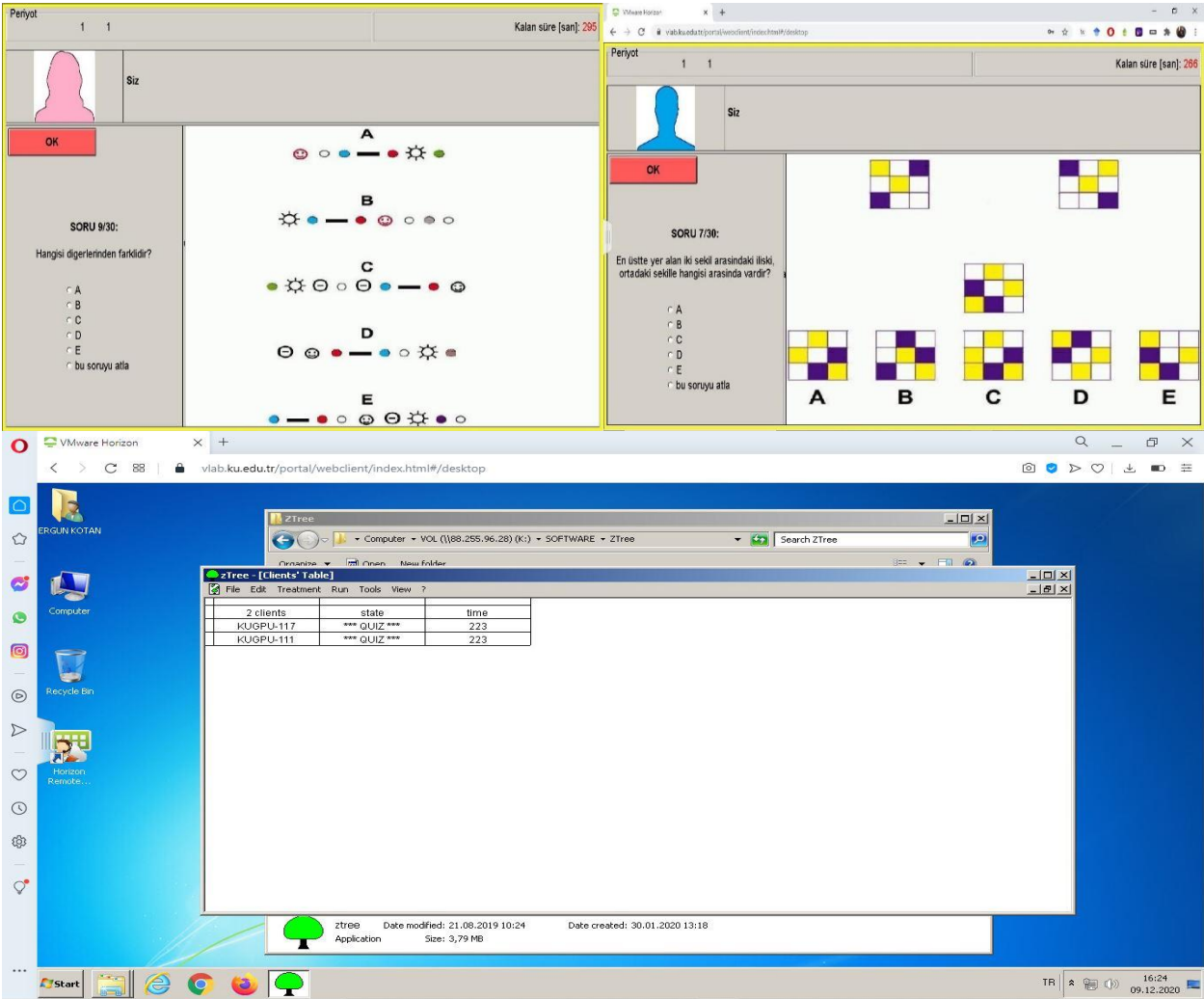


Figure 7: Depiction of the compatibility issue (normal screen vs. troubled screen)

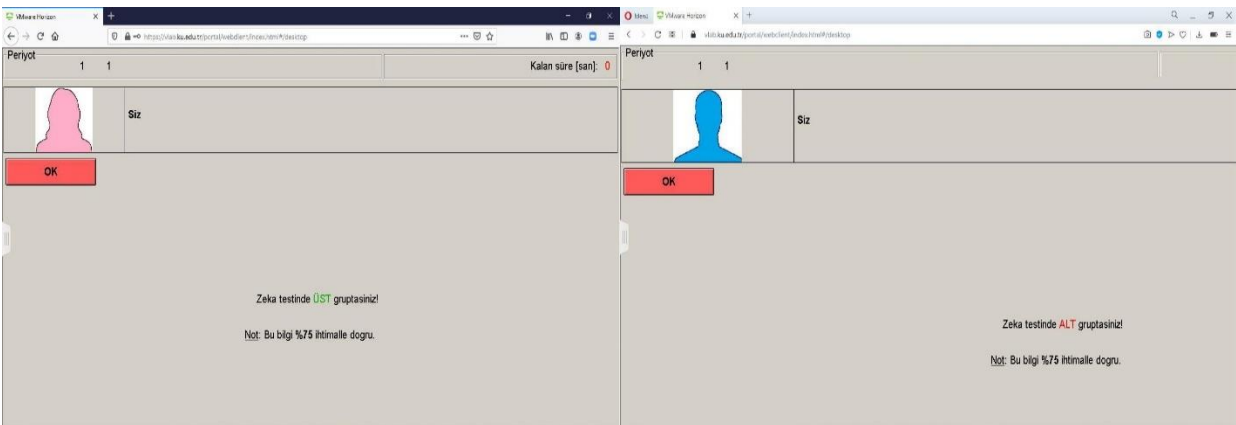




Figure 8: The question about disk sharing at the initial connection to the VLab

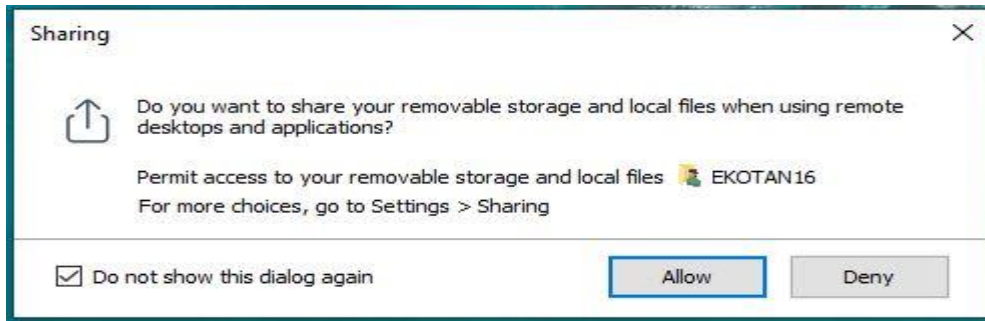


Figure 9: The option to connect a USB flash drive and the view of the local hard disk drive (Network Drive (Z:)) among the other networks on the file server

