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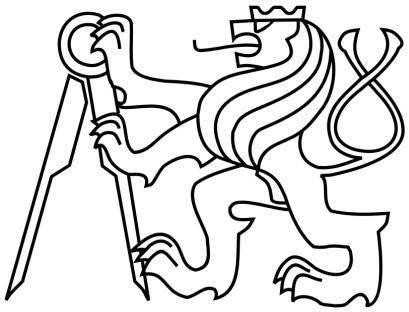

MASTER'S THESIS

Creation of a new GRASS GIS startup mechanism

Tvorba nového startovacího mechanismu v prostředí GRASS GIS

Supervisor: Ing. Martin Landa, Ph.D.

2020 Prague

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ZADÁNÍ DIPLOMOVÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

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Studijní program: Geodézie a kartografie

Studijní obor: Geomatika

II. ÚDAJE K DIPLOMOVÉ PRÁCI

Název diplomové práce: Creation of a new GRASS GIS startup mechanism

Název diplomové práce anglicky: Tvorba nového startovacího mechanismu v prostředí GRASS GIS

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Cílem práce je navázat na programovací část vytvořenou v létě 2020 v rámci mezinárodního programu Google Summer of Code (GSoC) a pomocí dvou průzkumů vyhodnotit přínos výrazných změn, ke kterým došlo. První část práce se zaměří na průzkum mezi středně pokročilými uživateli a porovná startovací mechanismus původní verze GRASS GIS 7.8 s novým řešením představeným po GSoC. Druhá část se orientuje na nové uživatele a implementuje tzv. "first-time" mód. Průzkumem založeným na jednoduchém úkolu dále zkoumá, zda je počáteční kontakt uživatele se softwarem při využití "first-time" módu příjemnější či nikoliv.

Seznam doporučené literatury:
Predicting Database Requirements for Geographic Information Systems in the Year 2000: Long-Term Design Issues for GRASS. August 1992.
Goran, W.D., Dvorak, W.E., Van Warren, L. and Webster, R.D., 1983, Fort Hood Geographic Information System: Pilot System Development and User Instructions, Technical Report N-154, USA Construction Engineering Research Laboratory, Champaign, IL.
https://www.wxpython.org/
https://grass.osgeo.org/

Jméno vedoucího diplomové práce: Ing. Martin Landa, Ph.D.

Datum zadání diplomové práce: 29.9.2020 Termín odevzdání diplomové práce: 3.1.2021
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Datum převzetí zadání Podpis studenta(ky)

ANNOTATION

The GRASS GIS startup mechanism could discourage new users from further working with this software or at least making it uncomfortable. This master thesis is built on the programming part performed in the summer of 2020 within the international Google Summer of Code program (GSoC) and uses two questionnaires to evaluate the benefits of significant changes that have taken place. The first part of the work focuses on a survey among intermediate users and compares the startup mechanism of the original GRASS GIS 7.8 version with the new solution introduced after GSoC. The second part is focused on newcomers and implements the special mode for first-time users. A survey based on a simple task further examines whether the user's initial contact with the software when using the "first-time" mode is more pleasant or not.

KEYWORDS

GRASS GIS, GUI, wxPython, Python, startup, GSoC, first-time user, software development, survey, questionnaire

ANOTACE

Dosavadní startovací mechanismus softwaru GRASS GIS mohl odradit nové uživatele od další práce s tímto softwarem nebo ji alespoň znepříjemnit. Cílem této práce je navázat na programovací část vytvořenou v létě 2020 v rámci mezinárodního programu Google Summer of Code (GSoC) a pomocí dvou průzkumů vyhodnotit přínos výrazných změn, ke kterým došlo. První část práce se zaměřuje na průzkum mezi středně pokročilými uživateli a porovnává startovací mechanismus původní verze GRASS GIS 7.8 s novým řešením představeným po GSoC. Druhá část se orientuje na nové uživatele a implementuje tzv. "first-time" mód. Průzkumem založeným na jednoduchém úkolu dále zkoumá, zda je počáteční kontakt uživatele se softwarem při využití "first-time" módu příjemnější či nikoliv.

KLÍČOVÁ SLOVA

GRASS GIS, GUI, wxPython, Python, startup, GSoC, first-time uživatel, vývoj softwaru, průzkum, dotazník

DECLARATION OF AUTHORSHIP

I hereby declare that the work presented here is, to the best of my knowledge and belief, the original result of my own investigations, except as acknowledged. All direct or indirect sources used are acknowledged as references.

In Prague ....

ACKNOWLEDGEMENT

First, I would like to thank my parents very much for their support during my studies. Second, I would like to express my great thanks to Martin Landa who inspired me a lot on my way to becoming a professional python developer. In the GRASS GIS open-source environment, I met an amazing community of incredibly inspiring people. Among those people, I would like to thank especially Anna and Vaclav Petras who were a great support to me during GSoC and even later on and brought a lot of valuable advice to this work. Finally, I would like to thank all GRASS users, whether complete beginners or advanced, who have participated in the questionnaires created in this work. They greatly contributed to the decision on how to increase the user-friendliness of GRASS GIS. Special thanks go to Pavel Karlovsky for his valuable comments on the text of the thesis.

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1 Introduction

According to the evaluation of the GIS Geography journal [1], GRASS GIS (Geographic Resources Analysis Support System) is one of the best software in the world of open-source software focused on Geographic Information System (GIS) in terms of numerical analysis. The history of GRASS, built for vector and raster geospatial management, geoprocessing, spatial modeling, and visualization, dates back to 1982 when the United States military started its development.. At the time of writing this thesis, the current stable version of the software is version 7.8, but as the number suggests, the planned version 8.0, which will be released in the spring of 2021, will introduce major changes. They are going to be largely related to the GRASS graphical user interface (GUI).

Although in the startup screen of version 7.8, there is a certain effort to provide the first-time user with the maximum possible help, the development community often encountered misunderstandings from the ranks of users. These complaints led to creating an implementation proposal known as the "Prague Roadmap" [2]. This proposal was the basis for the author's participation in the global Google Summer of Code program (GSoC) focused on bringing more developers into open-source software development. The task of GSoC was to change the sort of unfortunate GRASS startup mechanism so that it would be easier for first-time users to become familiar with GRASS. After GSoC changes, the startup screen – the biggest challenge for new users, was partially removed. The primary role for the data organization was taken over by the Data Catalog – a tree object whose functionality was significantly expanded. Now, the possibilities of managing data hierarchy components are even beyond the options previously available in the startup screen. The workflow of GSoC participation is described in detail on the GRASS wiki page [3].

Therefore, this work follows up on the complex topic of creating a better GRASS GIS startup mechanism. The main part of the work consists of two surveys, where the first one consists of two parts. The first part aims to evaluate the benefits of significant changes among the GRASS community and at the same time to propose a suitable solution for the GRASS startup mechanism where the old startup screen will be permanently removed. The second part of the first survey focuses on the improvement of the startup mechanism for first-time users. Already at GSoC, it was decided that some form of assistance to new users would need to be implemented. The second part of the survey finds out what options of the first-time help would be preferred. The second survey conducted one month later introduces a new special mode for first-time users (so-called "first-time" mode), which extends the default location concept with an infobar helping users manage the first steps. It examines whether users like the newly designed mockups of the infobar and gives them space to share ideas. Based on the analysis of the second survey, the infobar is improved and subsequently implemented.

1.1 GRASS GIS

GRASS GIS is a cross-platform desktop geographic information system (GIS) designed to work with geographic 2D/3D raster and vector data with SQL-based attribute management and vector network analysis. It supports both the command line and graphical user interface (GUI). Besides, it offers many spatial modeling algorithms, 3D visualization, as well as image processing routines pertaining to LiDAR and multi-band imagery [4]. It is open-source software published under the GNU GPL general license and managed and developed under the Open Source Geospatial Foundation (OSGeo). The GRASS system's influential users include NASA, NOAA, USDA, USGS, and many environmental consulting companies [5].

The power of software stems mainly from its Unix philosophy, where the software itself consists of a collection of more than 500 applications called modules. Each of these modules has only one task to perform. The real power of the software comes when the various of these modules begin to chain together, allowing the user to create even very complex applications. Most of these modules are written in C. However, above the whole system, PyGRASS as an object-oriented Python Application Programming Interface (API) stands, which hides the complexity of GRASS and provides access to the C-API capability of GRASS for geoscientists that are not familiar with C [6].

GRASS GIS had been using the versioning system since 1999 (CVS, then Subversion). Since January 2020, it has been developing on GitHub, a web version control using Git. Nowadays, most main changes take place in the Python language. For GUI coding, wxPython GUI toolkit is used. Besides improving the GRASS GIS startup mechanism, in summer 2020, the community presented a new website (see Figure 1) on the occasion of its 37th birthday, which offers a curated list of tutorials in different languages and links to videos.

Figure 1: New GRASS website's layout (Source: [7])

1.1.1 Data hierarchy in GRASS GIS

While in other GIS software it is usually customary to store work in so-called *projects* containing *map layers*, GRASS GIS keeps its unique data hierarchy, which has proven very useful over the years, especially for experienced users. Every GRASS GIS user has undoubtedly come across the following terms: Database, Location, Mapset, and Maps. These four representations form a tree of rules, which we can see in Figure 2.

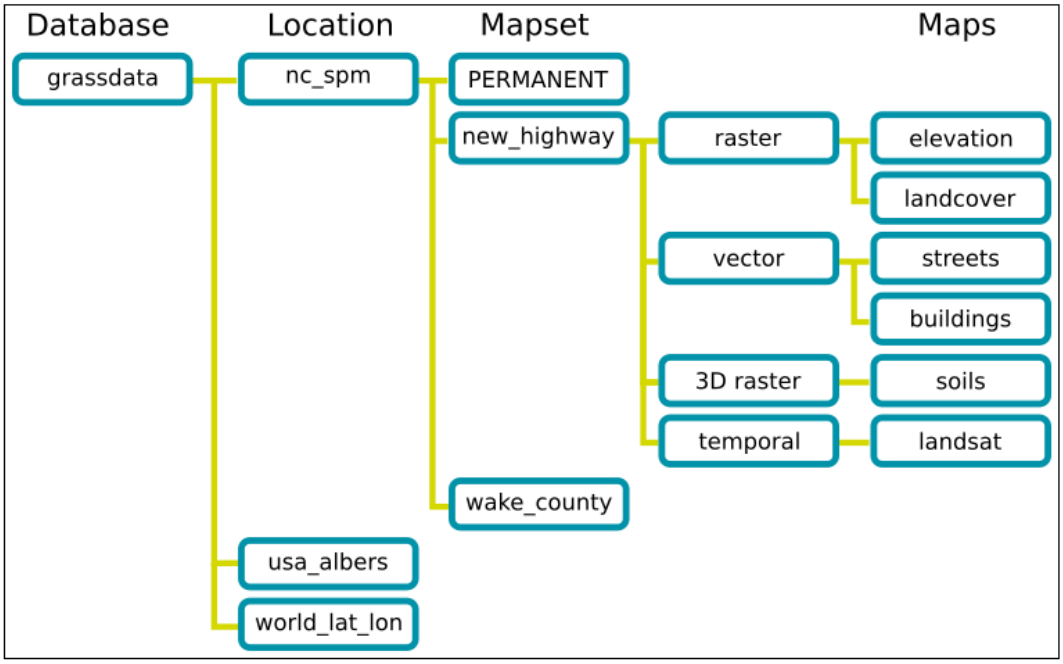


Figure 2: GRASS GIS 7 location structure (Source: [8])

The Database, which is built hierarchically at the top, has the character of a base directory, whose usual name is "grassdata". It contains Locations – collections of data with a common coordinate reference system (CRS). Therefore, Maps in the Mapsets contained in a particular Location will always have the same coordinate system.

It is also important to mention that a mapset named PERMANENT is automatically created when creating a location. Briefly speaking, the PERMANENT mapset is used to store general spatial data, which are also accessible but write-protected to other users who are working in the same Location as the Database owner. The PERMANENT mapset also holds the default region boundary coordinate values and resolution ("computational region" in GRASS terminology). This is important for raster analysis [8].

In the following text, the GRASS data hierarchy elements are already taken as standard terms, and the initial letters are lowercase.

1.2 State of Art before GSoC

Since the GRASS GIS version 7.8 (before GSoC) has considerably complicated setup, we need to define what the term *startup mechanism* means in connection with GRASS. It basically includes three things:

- the way GRASS GIS can be started. In the case of a Unix operating system, it is run from the command line.
- GUI (graphical user interface) components that the user encounters during startup. In the case of GRASS GIS version 7.8, these are the splash screen, startup screen, and Location Wizard. There may be situations where the requested mapset is locked (this happens if it is used by another process, or if the last session in this mapset ended in an error). If the running mapset is locked, we are first notified that there is a lock file with a .gislock extension in the mapset, and then asked if we want to delete this file. In this special situation, when running GRASS, we even encounter five different GUI components. In the case of the version after GSoC, the mentioned components are bypassed in most situations and we can move straight to the third point.
- the state instantly after startup – here we can talk e.g. about the state of individual Layer Manager tabs, and Map Display.

As we could notice, there are several GUI components that need to be clarified at the outset. Let's first look at the role of the individual GUI components in version 7.8 (before GSoC). Due to significant changes, the author of this work made during the GSoC, the role of the startup screen and Data Catalog in version after GSoC is very different compared to version 7.8. The Data Catalog takes over the role of the startup screen. The state after GSoC is clearly described in section 1.4. The author evaluates the benefits of the changes in Survey 1 Part 1. In both subsections 1.2 and 1.4, the GRASS GUI software components are arranged chronologically according to the order in which the user encounters them.

Startup screen versus splash screen

As Ed Foster stated in 1996 [9]: "Splash screens, as they are commonly called, are the graphic logos that display while the program is loading and identify the program while reminding you about the software publisher's copyright restrictions." So, it appears before the main software window starts and remains visible for a few seconds. If we try to find articles on the startup screen, we will not be very successful. Nowadays, this topic lives mainly on programming websites such as Stack Overflow. In some software, a startup screen can mean at the same time a splash screen if no other startup screen appears (among GIS software e.g. gvSIG, SAGA

GIS). However, generally speaking, a startup screen usually requires some initial action from the user to set up the software.

The startup screen is the first component of the GRASS GIS version 7.8 that the user encounters. It allows us to set all the above-mentioned components except maps and, in the case of locations and mapsets, also manage them in terms of renaming and deleting. The various historical versions of the startup screen can be seen in Figure 3. The one on the right corresponds to the version 7.5 (as well as 7.8).

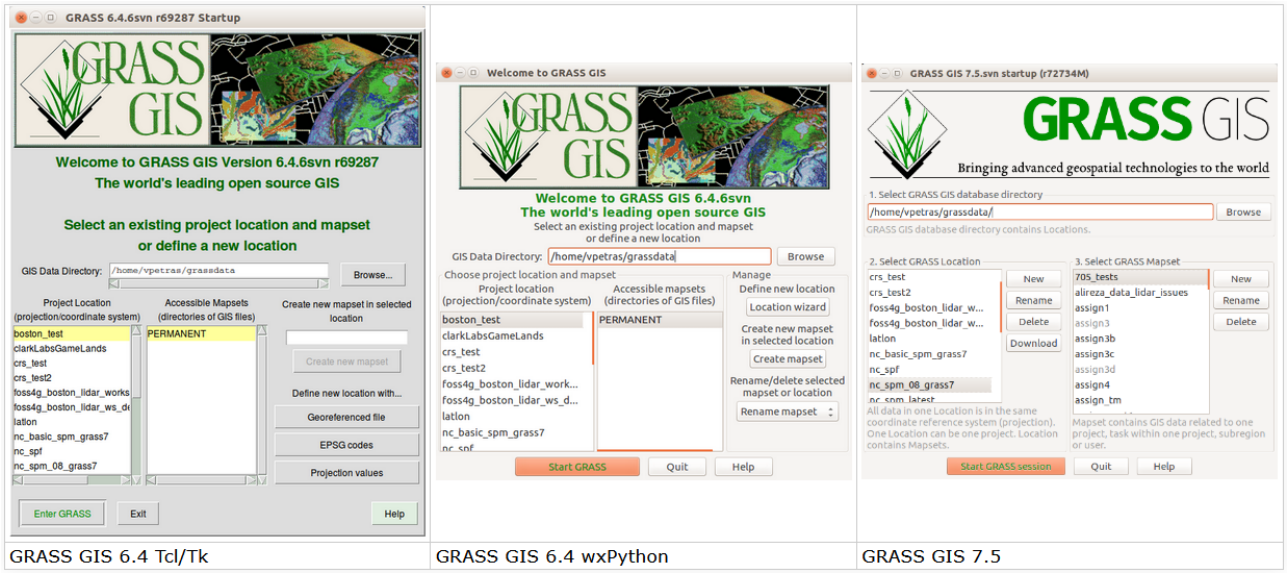


Figure 3: Historical versions of GRASS startup screen (Source: [10])

Location Wizard

Location Wizard is a software component, which has the character of a guide that appears when creating a new location. Therefore, the main task of the wizard is to define the Coordinate Reference System (CRS). It consists of four consecutive dialog boxes (the third box can be seen in Figure 4). A comparison of the Location Wizard before and after GSoC is included in subsection 1.4.

Layer Manager and Map Display

The peculiarity of GRASS GIS is that it does not consist of one software window, as is usually the custom, but directly of two. The topic of connecting Layer Manager with Map Display is, by the way, one of the proposed topics on GSoC [1]. As explained in more detail in the GRASS documentation, the Layer Manager provides a GUI for creating and managing maps. In Figure 5 we can notice five tabs – Layers, Console, Modules, Data, and Python.

[1] https://trac.osgeo.org/grass/wiki/GSoC/2020#GRASSGUI:Singlewindowlayout

Figure 4: Choosing EPSG code in Location Wizard in version 7.8 (Source: Personal collection)

In the Layer Manager version 7.8, after running GRASS we first see the Layers tab, which allows layers (maps) in Map Display to be switched on and off. After starting the session this tab is empty. The path to the current mapset and location can be noticed in the top bar in the Map Display window. In this case, the current mapset is called *demomapset* and is located in the location named *fire_grassdata*. GRASS GIS allows adding more Map Display windows. We can then manage layers in these windows via the Layers tab.

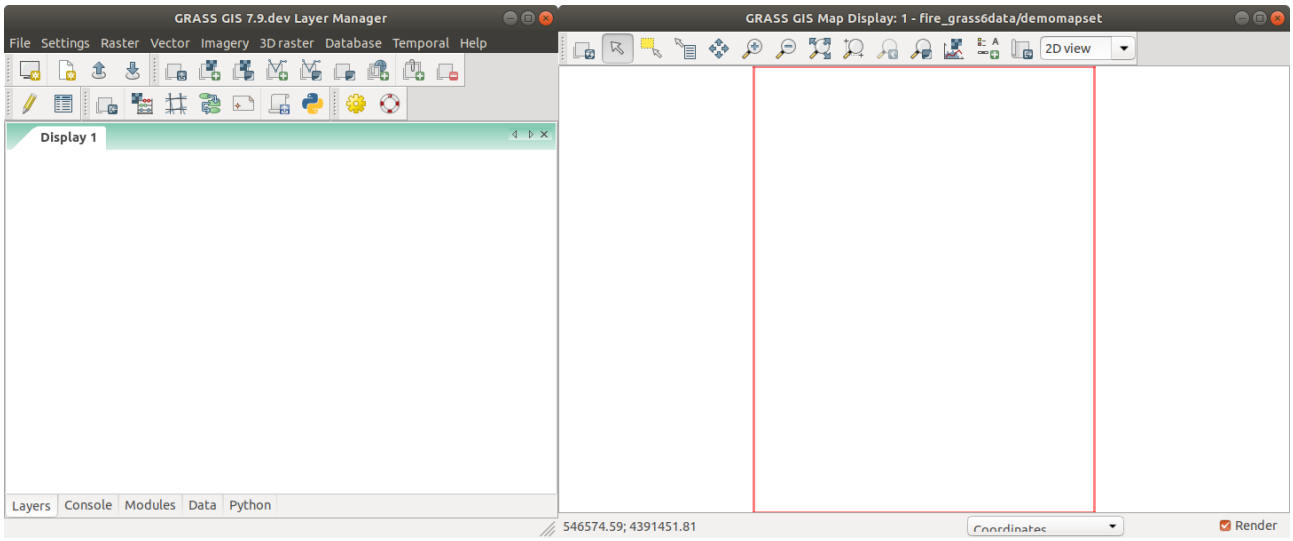


Figure 5: Layer Manager and Map Display in version 7.8 (Source: Personal collection)

In this work we will deal only with the Data tab, the explanation of other tabs can be found in the documentation [2].

Data tab

The Data tab in Figure 6 contains two objects – the Data Catalog (data hierarchy tree) and the toolbar, which allows e.g. updating and searching in the tree.

The Data Catalog enables to display the data located in the *current location* (equal to active location). Within the Data Catalog we are allowed to work with maps through the context menu - to display, rename and delete them, display their metadata, or to copy them from another mapset. However, the Data Catalog in version 7.8 does not provide management of mapsets, locations, or a database. This management is sort of hidden in the Settings/GRASS working environment menu.

The data in the current location are firmly connected to the Map Display window. If we want to see maps from a different location we can find in the mapset context menu the option for switching. We are able to switch between mapsets in the same location or between mapsets in different locations. If we copy the data to the mapset in another location with a different CRS, the projection takes place. GRASS GIS does not use the "on the fly" transformation.

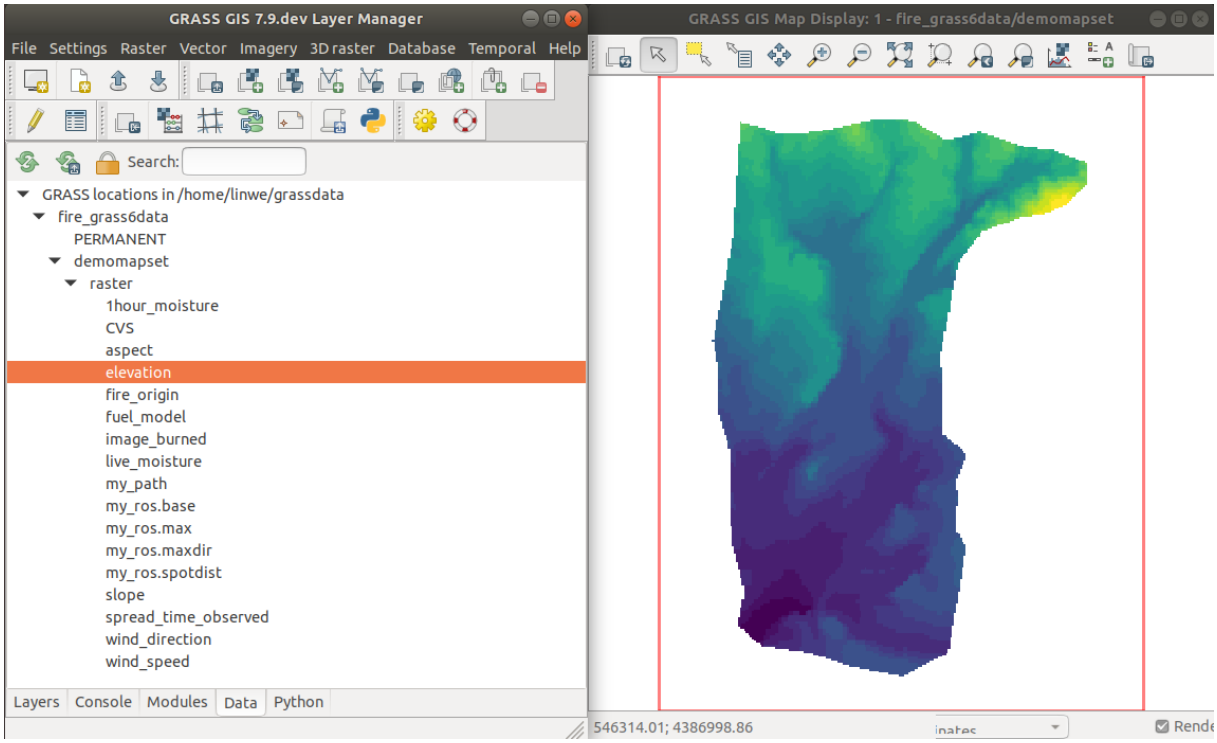


Figure 6: Data Catalog in version 7.8 (Source: Personal collection)

[2] https://grass.osgeo.org/grass79/manuals/wxGUI.html

1.3 Prague Roadmap

The data hierarchy described in subsubsection 1.1.1 proves its worth especially when used by experienced users of GRASS, however, for complete beginners, it is rather confusing. Especially if the above-mentioned main components (database, location, and mapset) have to be defined right at the start of the software in the startup screen, which is used since version 6.4. Although, in the startup screen of version 7.8, there is a certain effort to provide the first-time user with the maximum possible help (short description of data hierarchy, "Help" button), the development community often encountered misunderstanding from the ranks of users [3]. The disadvantages of GRASS mentioned in the evaluation of the GIS Geography journal [1] are also largely related to the current startup mechanism. According to this source, the main disadvantage of GRASS version 7.8 is mainly the clunky and dated user interface, defining projects on start-up and a steep learning curve to get started.

The general question, on which answer the community has still not fully agreed over the years, is whether to keep existing data hierarchy at all or change the whole concept and use only *project* and *map* terms, which is the usual standard for other GIS software. The `database/location/mapset` mechanism may indeed seem complicated at first glance, but we must keep in mind that many later problems will be avoided by clearly defining the CRS at the beginning and allowing only one coordinate system within one project. From the author's point of view, the advantage (perhaps from the point of view of first-time users maybe the disadvantage) is that GRASS GIS does not support "on the fly" transformation which shows differently projected data in the right place on the map. It guarantees that we cannot analyze data having a different coordinate system together, as could happen in ArcGIS or QGIS, for example. In GRASS GIS, we also cannot get into a situation that "on the fly" transformation does not occur at all, but despite this, it is allowed to display two layers of different coordinate systems on top of each other. This, of course, results in the incorrect rendering of the layers in the map window (may happen e.g. in SAGA GIS).

In 2017, the first suggestions on how to simplify this startup screen began to appear. In terms of implementation complexity, the simplest and most effective proposal seemed to be proposal A3 [4]. Based on this proposal, the implementation proposal known as the Prague Roadmap[5] was created in 2019 in Prague. The most serious changes concern the Data Catalog. They lie in supporting multiple databases, adding buttons to create existing or new databases, or adding new actions from the context menu to a database, location, and mapset node. Considering the disadvantages mentioned in the paragraph above, it was decided (August 31, 2020, unpublished video call) that the data hierarchy `database/location/mapset` will be preserved.

[3] `https://trac.osgeo.org/grass/ticket/3474`
[4] `https://trac.osgeo.org/grass/wiki/wxGUIDevelopment/New_Startup#ProposalA3Prague2019:Datatreeandbigbuttons`
[5] `https://trac.osgeo.org/grass/wiki/wxGUIDevelopment/New_Startup#PragueRoadmap`

The proposed changes in the Location Wizard are mainly related to the clarification of the first page, better naming of the given attributes, and speeding up the selection of the coordinate system in the dialog.

The same Data Catalog implemented in the Data tab is planned to be used within a startup screen. The proposal assumes the possibility of filtering in the Data Catalog based on the recently selected items. General startup GUI should be able to collect recently used mapsets and as well as databases and locations. When GRASS GIS launches for the first time, the "grassdata" working directory for storing locations, mapsets and maps should be automatically created in a reasonable place.

To sum it up, the startup screen proposed in Prague Roadmap consists of only one startup page, which has a Data Datalog in the center, and a toolbar with big buttons for creating or defining new or existing data components, such as a location or mapset. There is not any image available for that design, however, it follows very closely the previous proposal A2 [11] created by Garrett C. Millar, which we can see in Figure 7.

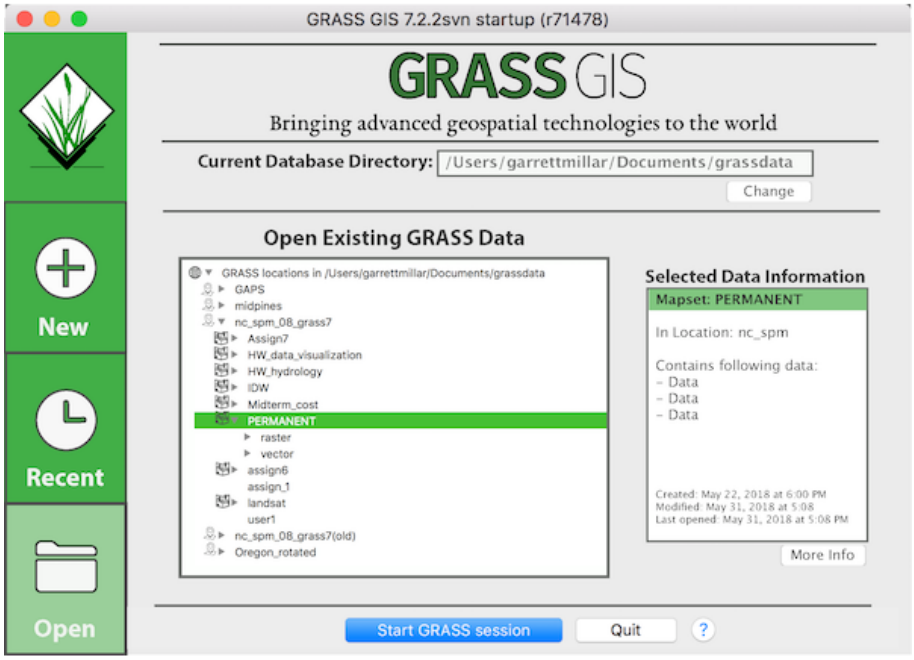


Figure 7: Proposal A2 (Gcmillar): Quick access through well-designed tabs on the side (Source: [11])

1.4 State of Art after GSoC

The changes that occurred during the GSoC are fundamental. At first, developers did not plan to remove the startup screen. The changes were to be based on Proposal A3, which suggested that the same Data Catalog, which is available in the Data tab after starting the session, will be part of the startup screen. During the implementation, however, all the functionality of the startup screen, including switching mapsets as well as locations and databases, was implemented to the Data Catalog, so it no longer made sense to keep this notion. At least definitely not the form in which it is in version 7.8.

Data Catalog

The main goal of GSoC was to improve the Data Catalog in such a way that enables a user-friendly organization of work. This is mainly about creating, renaming, and deleting mapsets and locations, which was previously possible through the startup screen and through Layer Manager's menu. However, completely new possibilities have been added. In Figure 8 we can see the all functionalities that have been newly implemented in the Data Catalog.

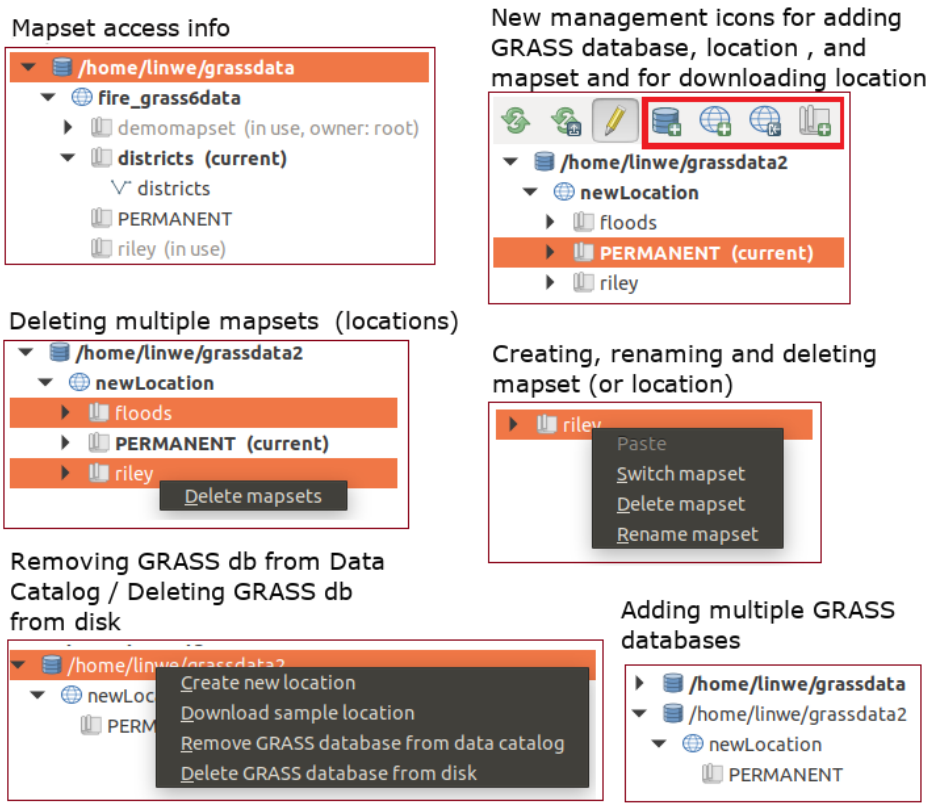


Figure 8: New functionalities in Data Catalog (Source: Personal collection)

GRASS GIS after GSoC allows a user to define multiple databases. New management icons in the upper toolbar offer intuitive creation of the mentioned data components. In the context menu, there are also new options for deleting several mapsets or locations. Though, probably the most visible changes are those related to the graphical representation of the Data Catalog. Next to the individual components, we can notice small icons distinguishing types of data hierarchy components. The Data Catalog also informs about access to individual mapsets (current, in use, and a different owner).

Another important thing is related to access to individual mapsets. In version 7.8, the startup screen informs about the lock and asks if the user wants to remove the lock. In order to completely take over the startup screen functionality by the Data Catalog, it is also necessary to warn the user that the mapset to which they are going to switch is locked. How this case was solved is clear from Figure 9. Because mapset locking was often confused with prohibiting editing outside the current mapset, the term was changed to *mapset in use*. This term can also be seen in the Mapset Access Info in the Data Catalog.

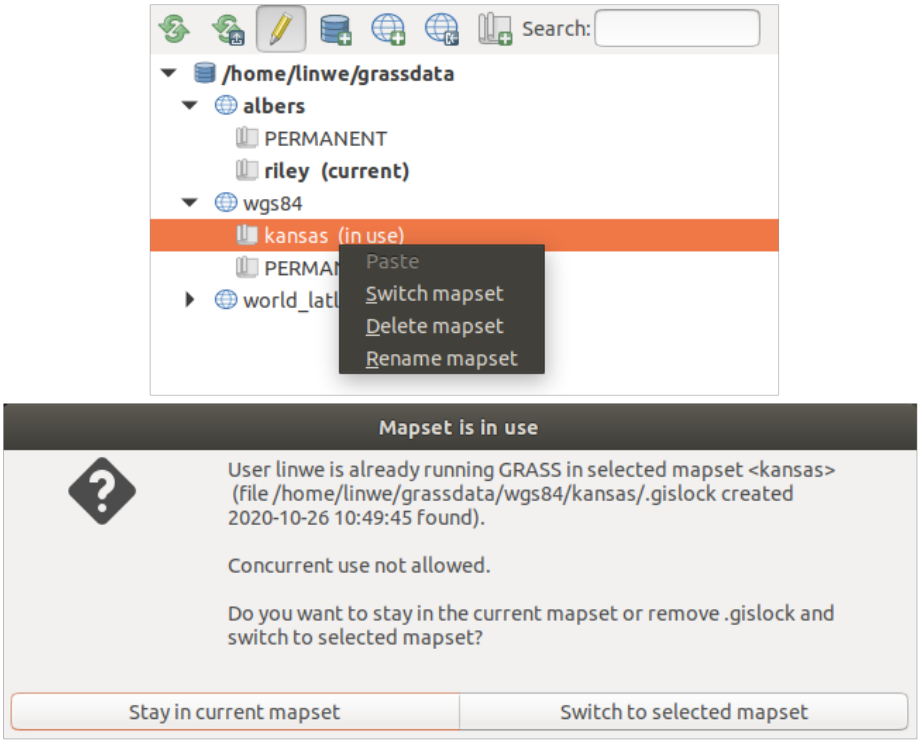


Figure 9: Switching to mapset in use in Data Catalog (Source: Personal collection)

Another substantive step forward was the graphic change of the icon enabling or disabling changes outside the current mapset. This icon has newly the bitmap of a pencil (instead of a bitmap of a lock in version 7.8) and protects a user from unwanted changes. If we do not enable editing, we cannot rename or delete any mapsets, locations, and databases. We can only work with data elements inside the current mapset. (The term "data elements" is more generic, in

the future Data Catalog could show also spacetime datasets and other data elements, not only raster/vector maps). However, even if we enable editing, we cannot delete a PERMANENT mapset. Similarly, we are not allowed to delete boldly marked **current** components in the Data Catalog.

Location Wizard

This guide to creating new locations has been slightly modified and streamlined. In particular, we can see it on the first page "Define a new GRASS location" in Figure 10. Checkboxes and simplified names are removed here. Furthermore, the GRASS database can be modified.

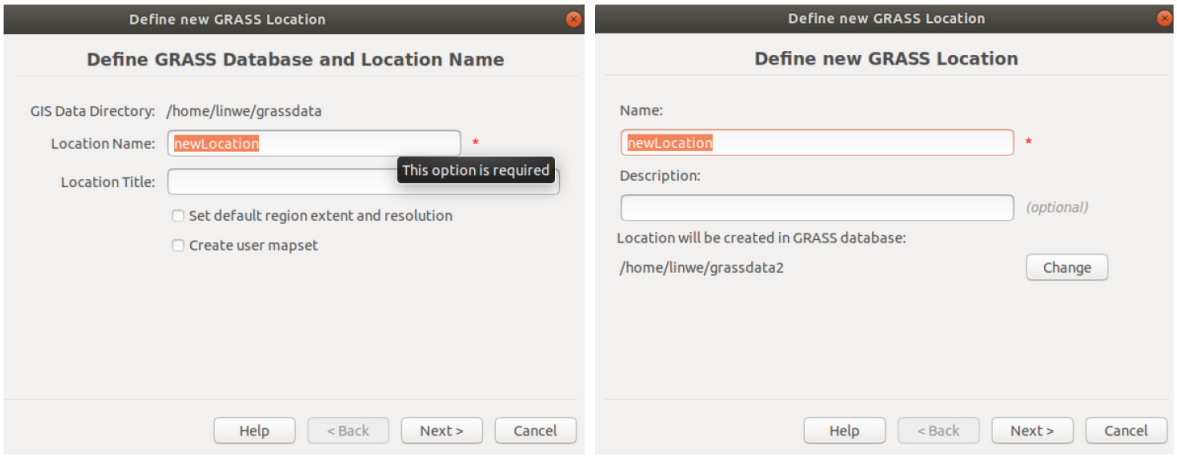


Figure 10: Location Wizard first page before and after GSoC (Source: Personal collection)

The second page is renamed to "Select Coordinate Reference System (CRS)". As we can see in Figure 11, the division into simple and advanced methods is abolished in the new version. Besides, CRS can be newly specified using a WKT string.

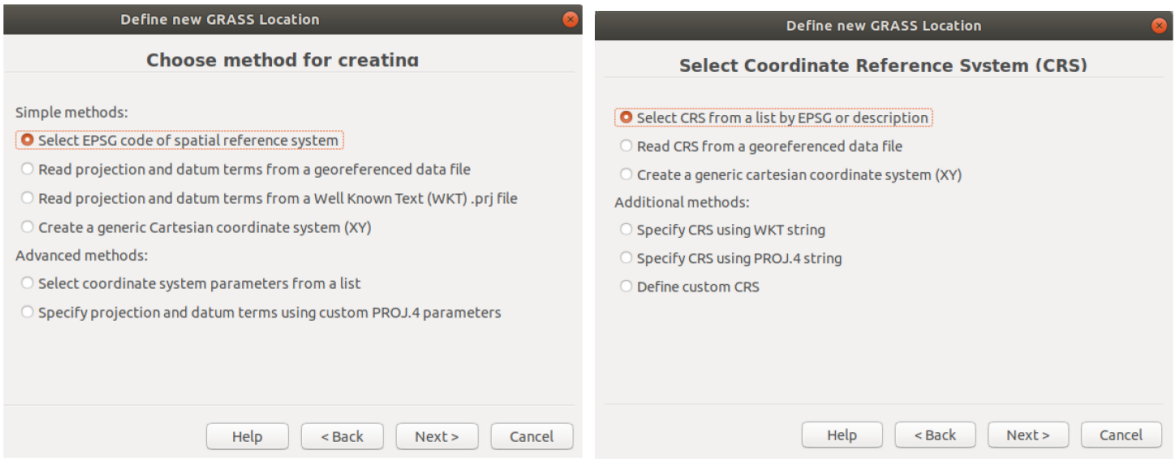


Figure 11: Location Wizard second page before and after GSoC (Source: Personal collection)

However, the essential change is related to the "Choose EPSG code" page. Now it supports dynamic EPSG search and the hyperlink which is changed dynamically according to a filter set by an user (see Figure 12). The last page of the Location Wizard called "Summary" remains unchanged.

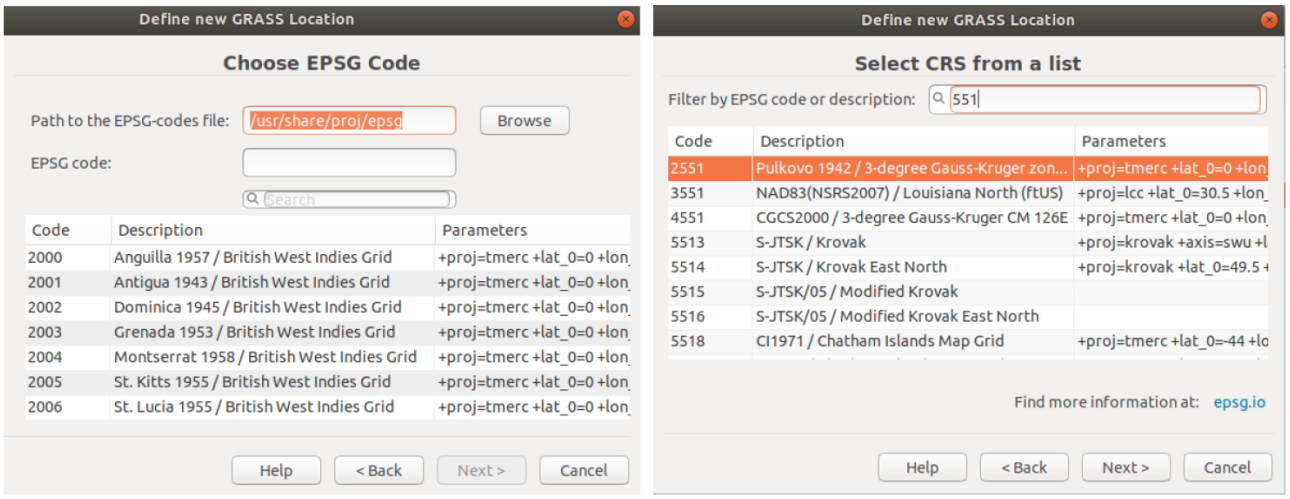


Figure 12: Location Wizard third page before and after GSoC (Source: Personal collection)

Startup screen

We can encounter three different situations when starting the GRASS GIS "after GSoC" development version:

1. **GRASS bypasses the startup screen and starts in the pre-prepared default location (also "demolocation" in development slang)** (see Figure 13). This situation occurs after the software is installed, that is when no used databases are stored in the settings. The default location called *world_latlong_wgs84* in WGS84 coordinate system (EPSG:4326) shows the correct organization of the data. Base data are stored in a PERMANENT mapset whereas already analyzed data belongs to another mapset, for example to the one named after a user. The current implementation does not show the World map included in *country_boundaries* layer immediately at startup, it is necessary to display the map using Data Catalog (see Figure 14). The splash screen does not appear.
2. **GRASS bypasses the startup screen if possible to start in the last used mapset** (see Figure 15). The situation when GRASS starts in the last used location/mapset is probably the most common. The software remembers the databases that were open when the last session was closed and opens them. The splash screen does not appear.
3. **GRASS launches in startup screen if the last used mapset is not in a usable state** (was deleted or is used by another process). In this special situation, GRASS starts in the same way as in version 7.8.

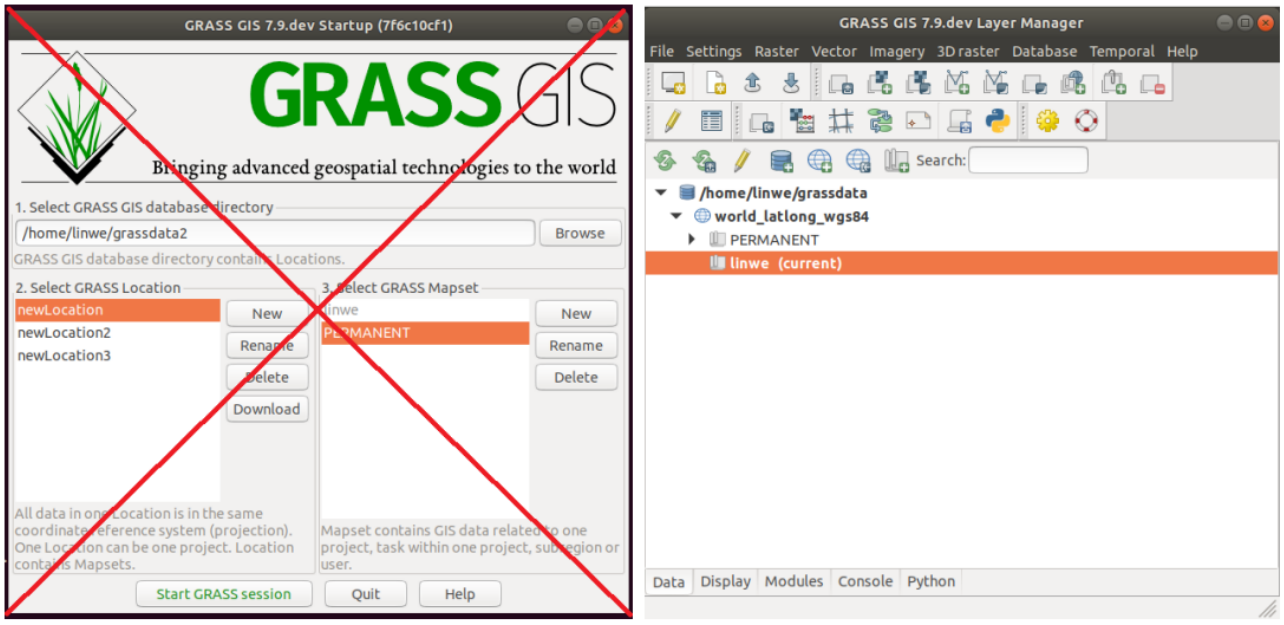


Figure 13: GRASS starts in the pre-prepared default location (Source: Personal collection)

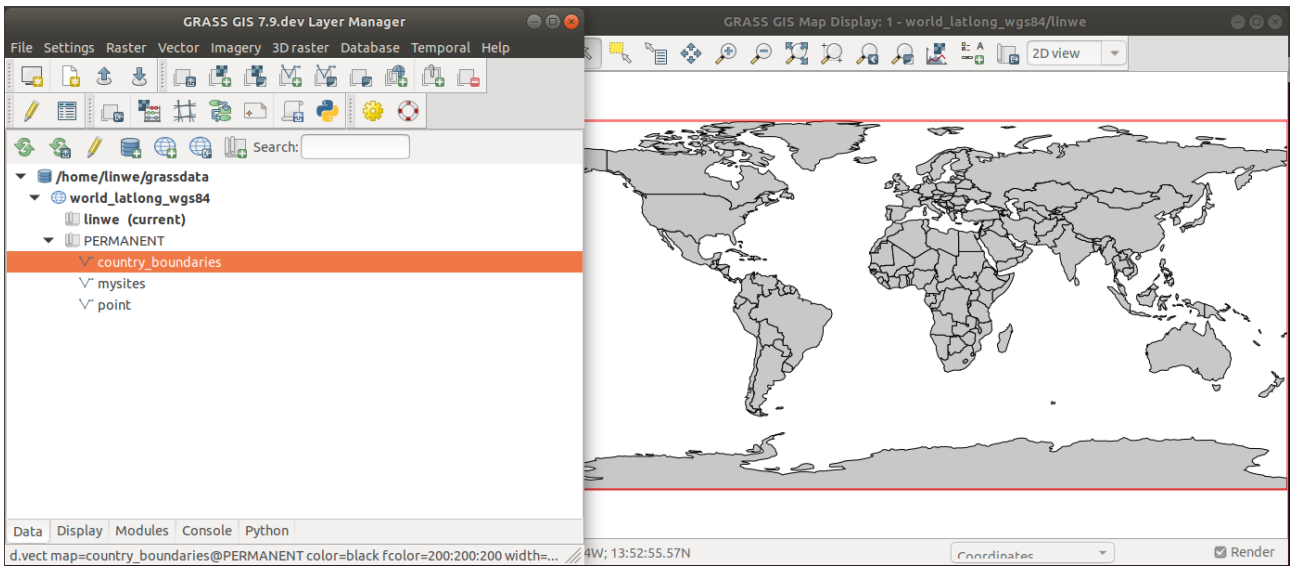


Figure 14: World map as a part of the default location (Source: Personal collection)

Various options for starting GRASS GIS

In addition to the software components that the user encounters during startup and to the state that the software finds itself immediately after startup, the startup mechanism also includes the way how GRASS GIS can be started. Because users of this software usually work under a Unix operating system, GRASS is usually run from the command line.

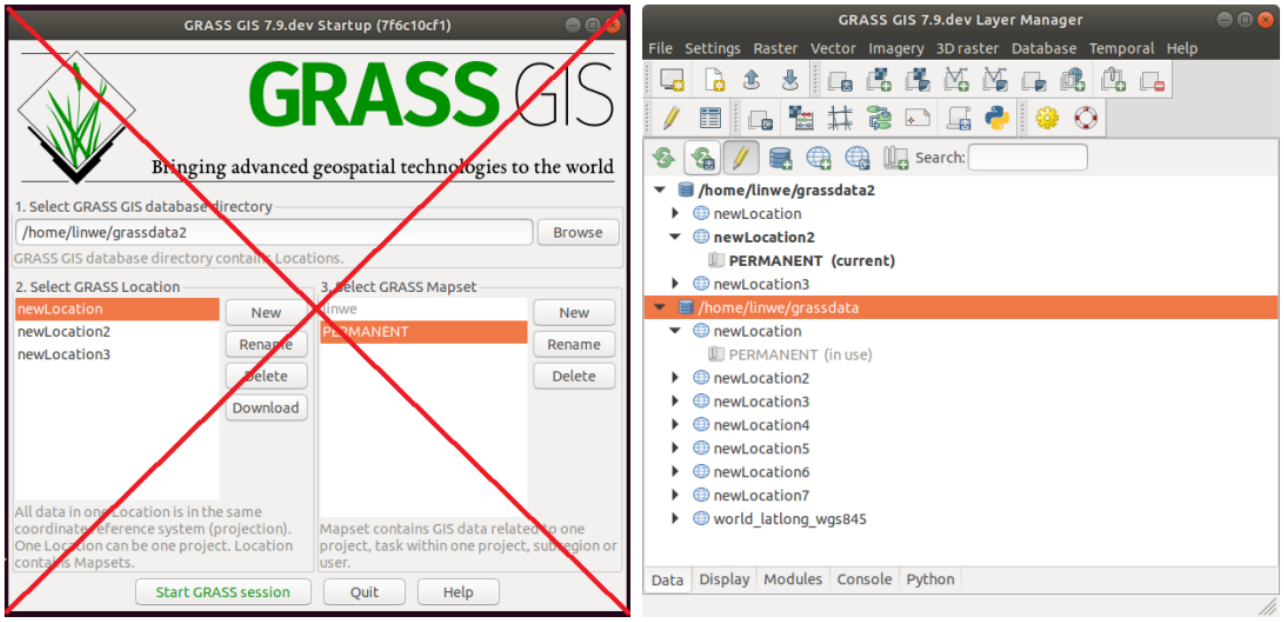


Figure 15: GRASS starts in the last used mapset (Source: Personal collection)

Advanced users often do not even run the graphical environment and perform all geographic analyzes using the command line. This is also why the command line window runs in the background throughout the work with this software. In the thesis, however, the author mainly focuses on first-time users. The software can be run from the command line in the following way [12]:

`:~$ grass79`
Start GRASS using the default user interface. In version 7.8, the user is prompted by the startup screen. Appropriate location and mapset must be either set by command line argument using the `:~$ grass79 $HOME/grassdata/location/mapset`, or by environment variables, or taken from the last GRASS session, specifically from a file in the path *$HOME/.grass7/rc*. After GSoC the startup screen appears only when the mapset is not in the usable state.

User interface can be futher specified by Flags:

`:~$ grass79 --gui`
Start GRASS using the graphical user interface. In version 7.8, the user is prompted by the startup screen. After GSoC the startup screen appears only when the mapset is not in the usable state.

`:~$ grass79 --text`
Start GRASS using the text-based user interface and do not show the startup screen. It is also possible to use `:~$ grass79$ --text /path/to/location/mapset` command.

```
:~$ grass79 --gtext
```

Start GRASS using the text-based user interface and show startup screen. As it is planned to completely remove the old startup screen, in version 7.9 after GSoC, the new function of the `--gtext` is not defined yet.

The possibilities of starting GRASS GIS can be further extended by the concept of *workspaces* which enables to save the current software settings and then open it, as we can see in Figure 16. However, the option to start a specific workspace from the command line or to start GRASS GIS from a File Manager using the file association of the workspace file (.gxw) is missing.

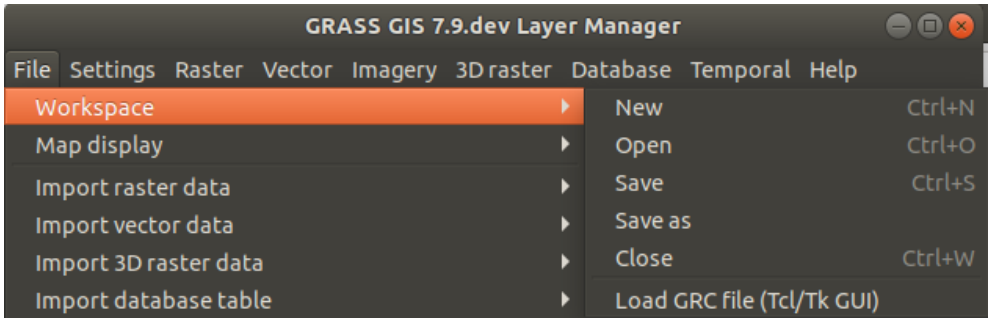


Figure 16: Management of workspaces in Layer Manager (Source: Personal collection)

1.5 Thesis objectives

The aim of the master thesis is to evaluate the changes made in the GSoC using questionnaires, propose the suitable solution for the GRASS GIS startup mechanism, and extend the startup mechanism by proposing and implementing a new solution of special mode for first-time users. There are two fundamental questions related to the mentioned proposals, which we will try to answer in the work:

1. **How to enhance the first-time user experience?**

   As already mentioned, data hierarchy in GRASS GIS can cause significant problems for newcomers. Therefore, the aim of this work is to propose a solution on how to enhance the first-time user experience (see subsection 6.1) and implement it.

2. **How to improve the GRASS GIS startup mechanism?**

   As mentioned in the previous subchapter, in the special situation where the last opened mapset is not in the usable state, the "old" startup screen still appears. This situation is rather a lack of a new solution introduced after GSoC. The important goal of this work is to propose a solution for how this shortcoming could be remedied (see subsection 6.2).

Already during GSoC, it was decided that some form of special mode for new users will need to be implemented. At the same time, however, some questions remained unanswered regarding the general startup mechanism and further direction of the GRASS GUI.

Therefore, Survey 1 Part 1 entitled **Help improve GRASS GIS startup mechanism and Data Catalog**, see Appendix A, does not deal only with the second key question; it is much broader. The goals are also to determine the level of user satisfaction/dissatisfaction with the new solution and obtain general user preferences regarding further improvements of the GRASS GUI.

As it was not clear how to grab the new special mode for first-time users, the first survey was extended by a second thematically different section called **Help create a better first-time user experience in GRASS GIS**, see Appendix B. The answers in this part of the survey are essential for deciding of what information the special mode for first-time users should contain and which implementation form to choose.

The aim of the second survey called **Help improve the special mode for first-time users** is to find out whether users like the proposed mockups of the infobar and give them space to share their ideas so that the implemented solution in this work is the best possible from an objective point of view (see Appendix C). Both Survey 1 Part 2 and Survey 2 deal with the first question, which prevails since all the performed implementations are based on it.

2 Enhancing the first-time user experience

Firstly, we need to define what we mean by the *first-time user experience*. As [13] states "In human-computer interaction and UI design, a first-time user experience (FTUE) refers to the initial stages of using a piece of software. It commonly includes configuration steps, such as signing up for an account. Every user of a service has his/her FTUE, even if he/she has extensive experience with using a similar product. Patience, time investment, and intuitiveness are factors for a user's FTUE. Software services generally have different layouts, styles, graphics, and hotkeys which must be identified to contribute to a user's learning, mastery, and efficiency of the software."

Many articles are dealing with both improving the first-time user experience and evaluating it. For instance, [14] deals with the use of FTUE embedded in games on mobile devices. It implies that FTUE has the power to affect user perception in elements of usability – an integral part of software development and talking about maximizing the effectiveness, efficiency, and satisfaction of the user. From a game design perspective, FTUE is impactful. Similarly, [15] investigates the experience of users who use new gesture control features of smartphones and tablets for the first time. The study reveals the advantages and disadvantages of new gesture control features and based on results suggests improvements regarding the design. Also interesting is the work [16] which studies the first-time user experience in a website-based exam system. As in the previous article, the conducted survey identifies several shortcomings that may be improved in the future.

The first-time user experience is mainly related to the initial user steps, so it is often related to the startup mechanism. So let's look in the following subsection at selected GIS software to examine if they use any features that enhance the first-time user experience or even the user experience in general. Then we move even beyond GIS and look at some other interesting ways how to improve the first-time user experience.

2.1 GIS software

In Figures 17 and 18 we can see graphs of the 10 highest rated GIS software and the 10 highest rated free GIS software in 2020, as stated in the evaluation taken by GIS Geography online journal [1]. The evaluation is performed on a point scale from 0 to 10 in four categories - *cartography, analysis, editing, and data management* which are subsequently averaged. We must keep in mind that this evaluation is very indicative, as each software has different strengths. GRASS GIS takes the leading position in the *analysis* category, with a rating of 9.8 out of 10, which is comparable to FME and ArcGIS Pro, but in other aspects, it loses significantly.

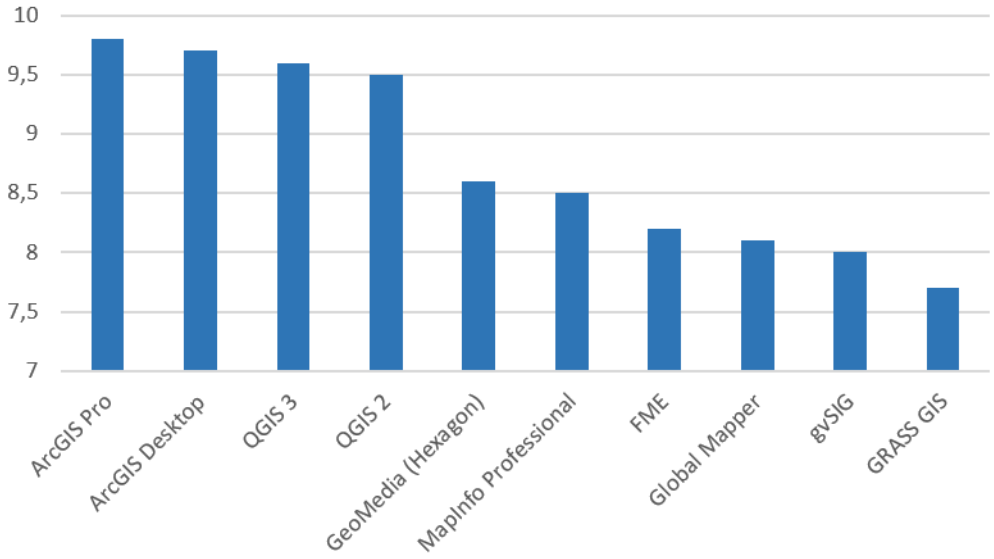


Figure 17: Top 10 GIS Software in 2020 according to GIS Geography journal [1]

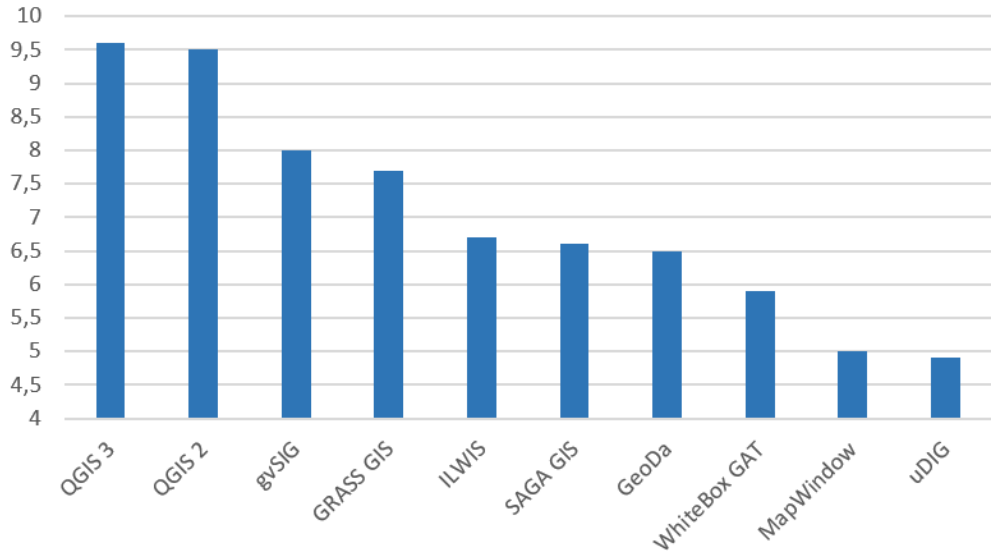


Figure 18: Top 10 free GIS Software in 2020 according to GIS Geography journal [1]

For the following analysis, the three highest-rated proprietary software were selected - ArcGIS Pro (ESRI), GeoMedia (Hexagon), and MapInfo Professional (Pitney Bowes) as well as the four highest-rated free software (excluding QGIS 2 and GRASS GIS). The software is analyzed using the following three questions:

- What data hierarchy does the software use compared to GRASS GIS?
- Has the software startup screen? And if so, is always displayed? How does it look like?
- Does the software have features for enhancing the first-time user experience, and if so, in what form?

The information obtained about proprietary GIS software is summarized in Figure 19.

GIS software	Data hiearchy in comparison with GRASS GIS	Has startup screen? Is always displayed? How does it look like?	Features enhancing first-time user experience
ArcGIS Pro 2.4	**Project file (.aprx)** - similar to GRASS workspace (.gxw)	**Yes**, startup screen always displayed	**Startup screen** - very straightforward and provides four different types of templates
	Map - associated with Map Window, possible to have several Maps (Map Windows)	Open options: Open recent projects, open another project	
	Map - has one CRS similarly as GRASS location but can contain **layers** with different CRS which are On the fly transformed to the Map's CRS	Create options: Blank Templates (Map, Catalog, Global Scene, Local Scene, Start withnout template (can be saved later)	**Main software window** - no features that should specifically help the first-time user
GeoMedia Advantage 2020	**GeoWorkspace file (.gws)**- as GRASS workspace (.gxw)	**Yes**, always displayed. It has a form of small dialog box for selecting GeoWorspace file	**Startup screen** - this is only a dialog box for selecting a GeoWorkspace file
	Warehouse (.mdb) - has the character of a location. You need to define it first, then connect to it. It has a clearly defined coordinate system. One GeoWorkspace file can have multiple Warehouses attached.	Open options: Open an existing GeoWorkspace file	The software provides two GeoWorkspace templates
		Create options: Create a new GeoWorkspace file using Blank file or Template,	**Main software window** - It does not provide any elements that would help a newcomer to start. Connection of warehouses is very unintuitive and just displaying an ordinary shapefile costs a lot of effort.
MapInfo 2019	**Workspace file (.wor)** - as GRASS workspace (.gxw)	**Yes**, startup screen always displayed, occupies the entire computer screen	**Startup screen** - very straightforward, provides Getting Started info, MapInfo News, hyperlink to connect with User Groups
	Map - associated with Map Window, possible to have several Maps (Map Windows)	Open options: Open blank workspace, recent workspaces, sample workspace, last saved session (not for first-time user)	**Furthermore, it** provides one very comprehensive Washington DC Sample
	Map - has one CRS similarly as GRASS location and contained layers have the same CRS		**Main software window** - no features that should specifically help the first-time user, all is included in startup screen

Figure 19: Summary of selected proprietary software (Source: Personal collection)

In terms of enhancing the first-time user experience, the most interesting deeds are the startup screens of the ArcGIS Pro 2.4 and MapInfo 2019 software. The startup screen of MapInfo 2019 (see Figure 20) atypically occupies the size of the entire computer screen. It provides links to news or links to videos on YouTube that can help first-time users. In the upper right part of the startup screen, it is possible to run help, which has the character of a separate desktop application. In the left part, there is a simple bar allowing us to choose a workspace we want to work in. We can open an empty workspace, sample workspace with a map of Washington DC, or choose another previously saved workspace in the directory path. If we run the software again, the Open Last Saved Session option will be added to the startup screen.

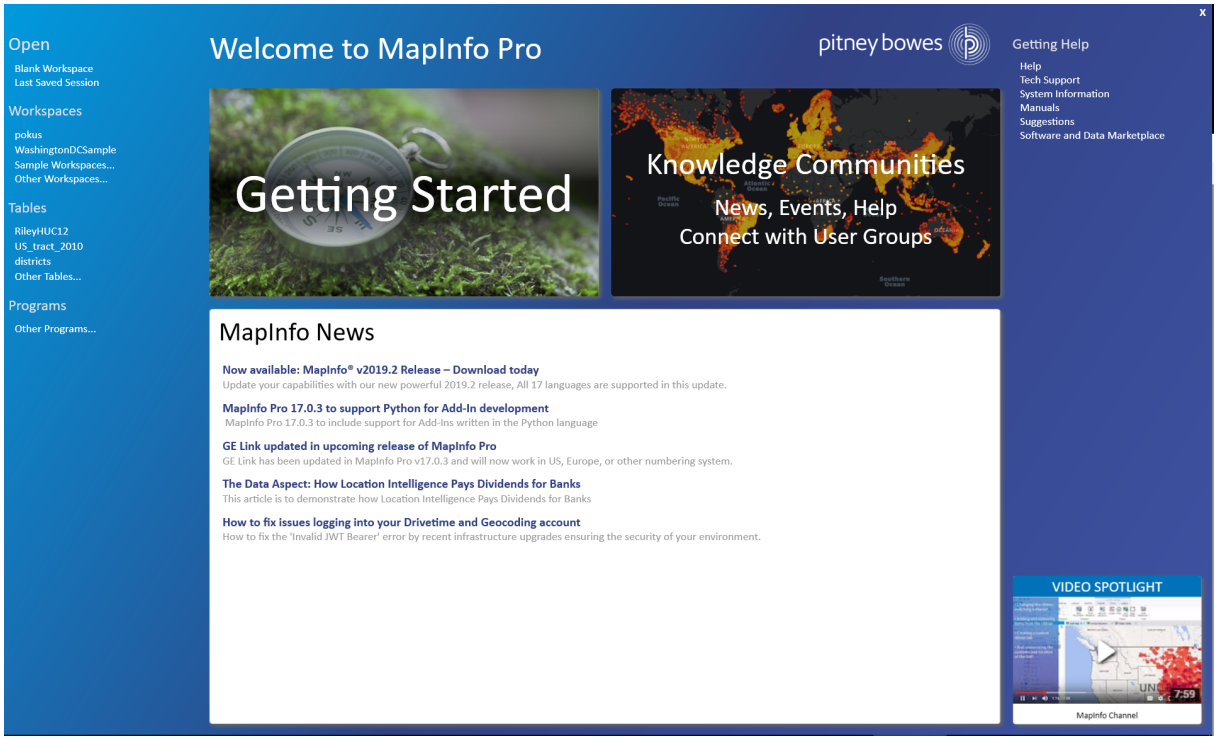


Figure 20: MapInfo Professional 2019 startup dialog (Source: Personal collection)

The ArcGIS Pro 2.4 also has its startup screen. Here we can open recently saved projects or select from pre-prepared templates (Map (standard), Catalog, Global scene, and Local scene). Another option is to select an empty sheet.

The information obtained about free GIS software is summarized in Figures 22, 23. In terms of improving the first-time user experience, QGIS 3 is the most interesting. After the introduction, the user is redirected to the main software window informing him about community events and improvements. Here the user can choose an empty project template or open sample datasets (North Carolina, South Dakota, Alaska) provided along with installation. QGIS 3 also shows an informative warning message (see Figure 21) that appear quite often in a variety of situations. This infobar can be helpful for new as well as experienced QGIS users.

Figure 21: Informative warning message in QGIS 3.14 (Source: Personal collection)

In the cross-section of all selected GIS software, we can notice that the data hierarchy is quite different. The truth is that two world-famous representatives of GIS software – ArcGIS Pro and QGIS 3 – have similar data organization into projects. However, in the data hierarchy

GIS software	Data hiearchy in comparison with GRASS GIS	Has startup screen? Is always displayed? How does it look like?	Features enhancing first-time user experience
QGIS 3.14	**Project file (.qgz)** - as GRASS workspace (.gxw) **Project** contains layers **Layers** in one project do not have one clearly defined directory as it is in GRASS GIS	**Yes**, always displayed. It has a startup screen but not as a separate dialog box. The News and selection of project are part of the main software window.	Welcome to QGIS window referring to QGIS website **Main software window** - informs a user about news **Infobars** - general information and warnings for all users
gvSIG 2.5.0	**Project file (.qvsproj)**- as GRASS workspace (.gxw) **Layers** in one project do not have one clearly defined directory as it is in GRASS GIS	**No**, it does not have any startup screen. When started an empty map window opened.	**No features**, however everything is quite straghtforward.
ILWIS 3.3	The data is similarly to GRASS stored in one place in disk - in the **home directory called Data.** The imported layer is saved in Data directory as an ILWIS object with the * .ioc extension	**No**, it does not have any startup screen.	**No features**.
SAGA GIS 2.3	**Project file (.sprj)** - as GRASS workspace (.gxw) Displayed **layers** do not have their given folder. They can be stored anywhere on the disk.	**Yes**, after the second start of SAGA GIS, a small selection dialog box appears. First start displays blank Map window. Options: Blank page, the last software state, last running projects	**No features.**

Figure 22: Summary of selected free GIS software (Source: Personal collection)

of the other two proprietary software GeoMedia and MapInfo, the term " project " does not appear at all. It is therefore good to realize that we may consider " project " as a standard element of data organization, especially for free GIS software, but after looking at proprietary software we find out that data organization across software is surprisingly different not only from a technical point of view but also in terms of different names.

Startup screens appear in some form in all selected proprietary software. For GeoMedia, it is a small dialog box whose purpose is purely organizational – choose the GeoWorkspace you will work in. For ArcGIS Pro and MapInfo, startup screens play a more important role. It tries to impress users with both modern design and the services they offer. Similarly, QGIS tries to make contact with the user from the beginning – it refers to news and displays info bars.

It is surprising how much of a difference there can be between proprietary GIS software in terms of efforts to enhance the first-time user experience. With the GeoMedia software, the author did not manage to record any effort at all, on the contrary, MapInfo is very generous

GIS software	Data hiearchy	Has startup screen? Is always displayed? How does it look like?	Features enhancing first-time user experience
GRASS GIS before GSoC	**Database** has the character of a directory containing Locations. **Location** (Project) defines in which coordinate a user work. It contains Mapsets. **Mapset** (Subproject) gathers GIS **layers** related to one project task.	**Yes,** it is displayed almost always. It is not displayed only if we use the --text Flag, or if we specify by argument the mapset we want to open.	**No features**.
GRASS GIS after GSoC	same as before GSoC	**Yes**, but only if a mapset is not in a usable state (was deleted or is used by another process). In this special situation, GRASS starts in the same way as in the version 7.8.	**No features**. However, according to Survey 1 Question 1, improving the Data Catalog has enhanced the user experience, regardless of whether it is the first-time user or not.

Figure 23: Summary of GRASS GIS software (Source: Personal collection)

to its user from the very beginning and uses modern technologies in the startup screen, such as videos on YouTube. Despite the fact that in some of the selected software there is a certain effort to better interact with the initial user, none of them contains any First Run Wizard incorporated directly in the main software window (as offered by Zoner Photo Studio X, see the next chapter 2.2). However, it may not be necessary. Whether any help at all makes sense and is not rather counterproductive strongly depends on the complexity of data organization in particular software. For example, gvSIG software does not have any startup screen or helpful explanation, although it can be assumed that the new user will find his way around without any problems. GeoMedia also lacks any interactive features, however, as data organization is more complex to understand, it is likely to be a much more inconvenient start for users.

As known, GRASS GIS went a different way from the beginning. Not only in data organization. The difference between GRASS and other GIS software goes far beyond the startup mechanism or data organization. Let's remember the unique Unix philosophy, where the software consists of a collection of small applications called modules, or the ability to call these modules from the command line. It is, therefore, interesting to note that the comparison of GRASS GIS with other GIS software does not provide significant inspiration for other implementations associated with the improvement of the startup mechanism, which requires (and probably deserves) a completely unique solution whose roots were laid already in the summer of 2020 by GSoC implementations. However, the comparison offers an interesting look at this topic, which is not talked about much, but certainly has a big impact on the whole software. The evidence may be, after all, user complaints[6] about the problematic startup mechanism in versions before GSoC. We do not have to look for inspiration only in GIS software. The interaction with a first-time user is a completely general thing in all types of software.

[6] `https://trac.osgeo.org/grass/ticket/3474`

2.2 Other software

In this subsection, the author presents several interesting solutions for the enhancement of the first-time user experience in other software. It doesn't have to be just a first-time user experience. Generally speaking, a good user experience means that the user does not need a manual since everything is ready and straightforward. The user is led through the process with the guided tour or a combination of implicit and explicit action cues that show the way [17]. The author found two interesting ways to enhance the first-time user experience which are the inspiration for Survey 1 Part 2 Question 1 and Question 2. This work focuses on software solutions, however, there are also mentioned several examples of web solutions.

The first option, which is directly related to the improvement of the first-time user experience and often replaces the startup screen, is the First Run Wizard. It can take the form of a configuration (see [18], [19]) or explicitly educational. As GRASS GIS has a steep learning curve, this work is mainly about the educational form. An interesting example of an educational First Run Wizard is offered by the Zoner Photo Studio X software. As can be seen in Figure 24, the guide consists of five parts.

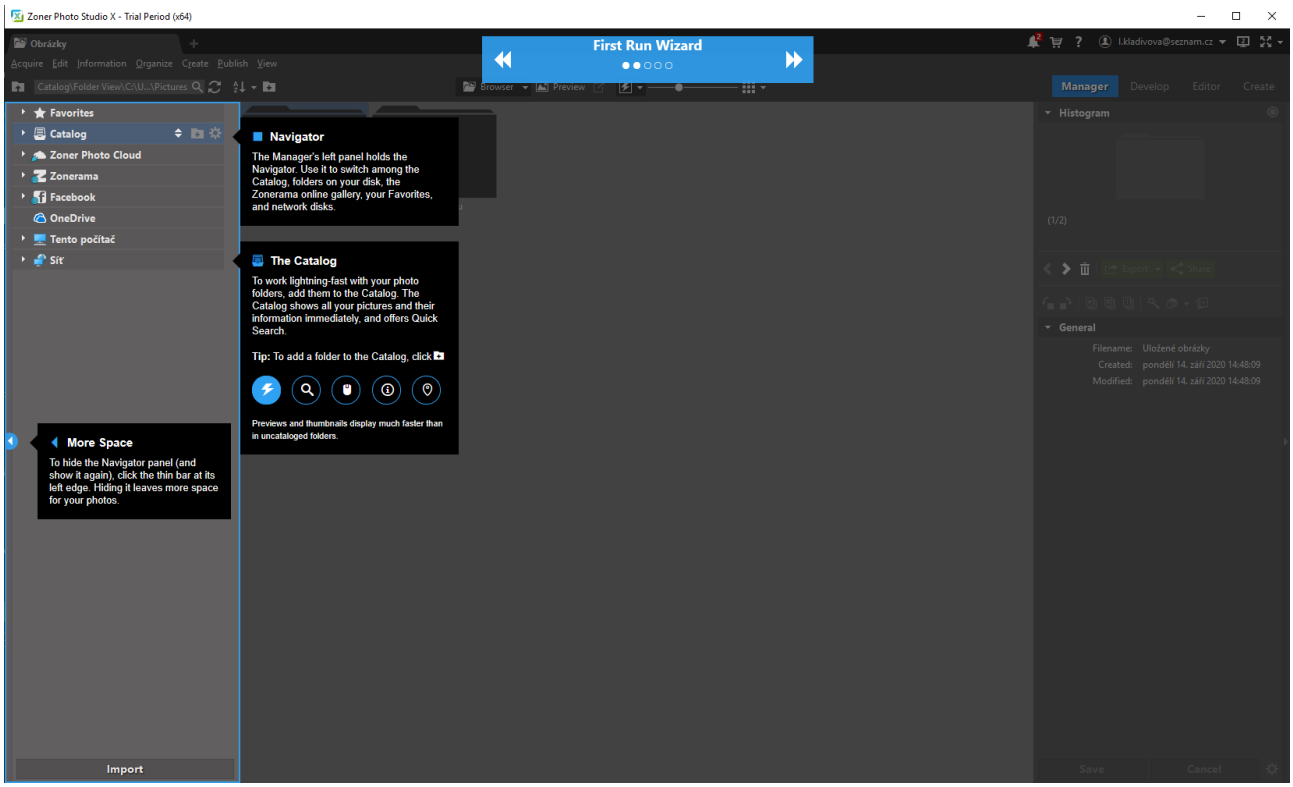


Figure 24: Second page of First Run Wizard in Zoner Photo Studio X (Source: Personal collection)

The first two sections introduce the software and main tabs. The following two pages of a guide describe photo thumbnails and zooming. The last page of the wizard lists the right toolbar and the three individual modules – Manager, Develop, and Editor. The main software components described in the wizard are always marked with a blue frame and the individual information windows are assigned to a particular part by arrows. The wizard is not only at the beginning, but also when using the above-mentioned modules for the first time.

The second example – infobar – may not only improve the first-time user experience. It most often provides a globally visible means of alerting users and publishing notifications. Presenting basic information or notifications to the user may also include a button to perform a follow-up action, as in the example in Figure 25.

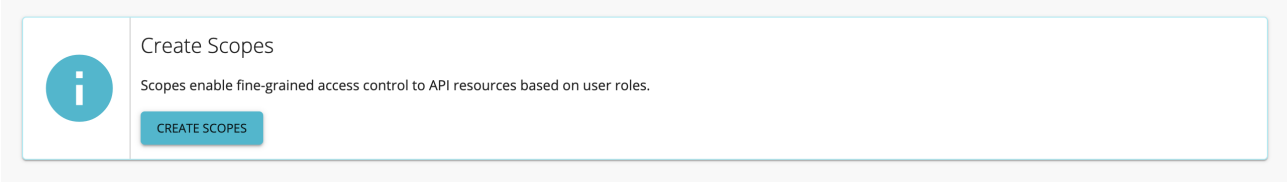


Figure 25: Advising infobar in API Manager (Source: [20])

An infobar usually enhances the general user experience. The exception is, e.g., the infobar in Matlab Simulink (see Figure 26) having the character of advice for the first-time user.

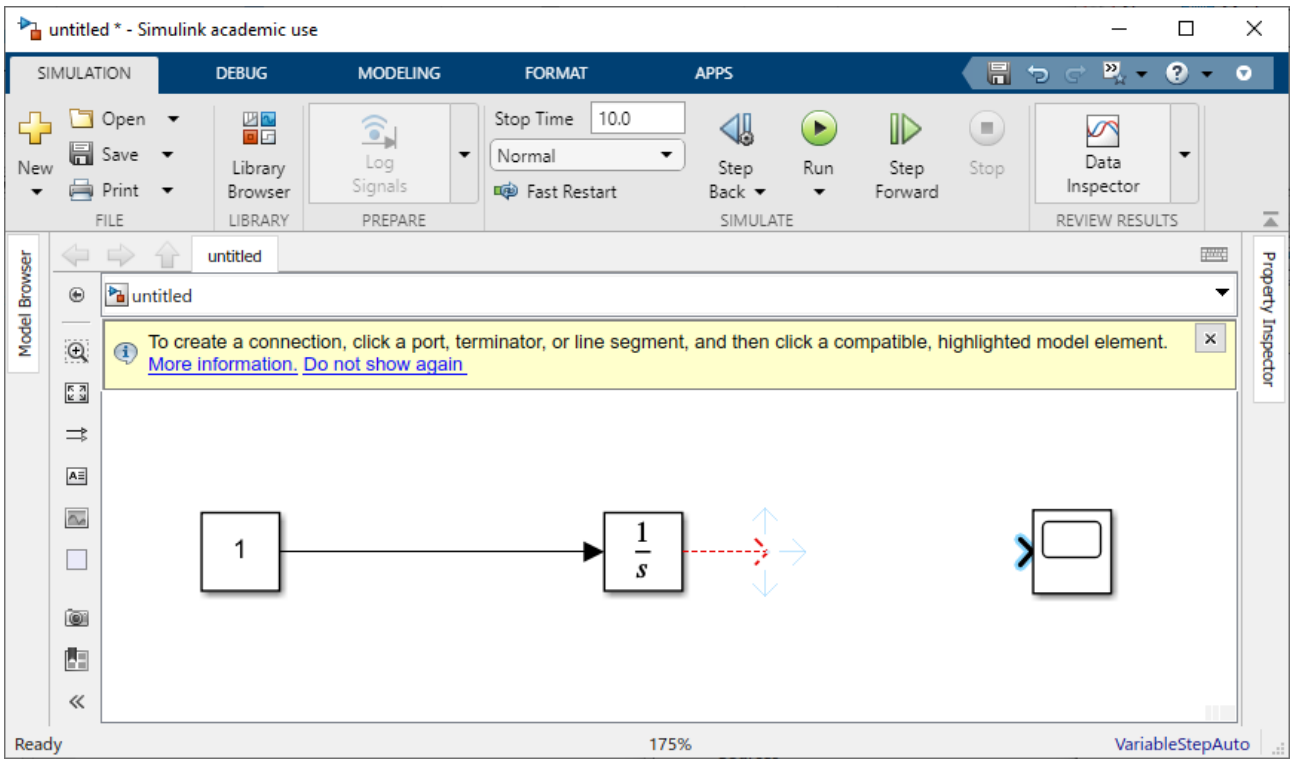


Figure 26: Advising infobar in Matlab Simulink (Source: Personal collection)

The topic of infobars is modern mainly in the web or smartphone world, where a lot of interesting designs are created, some examples can be seen in Figures 27 and 28.

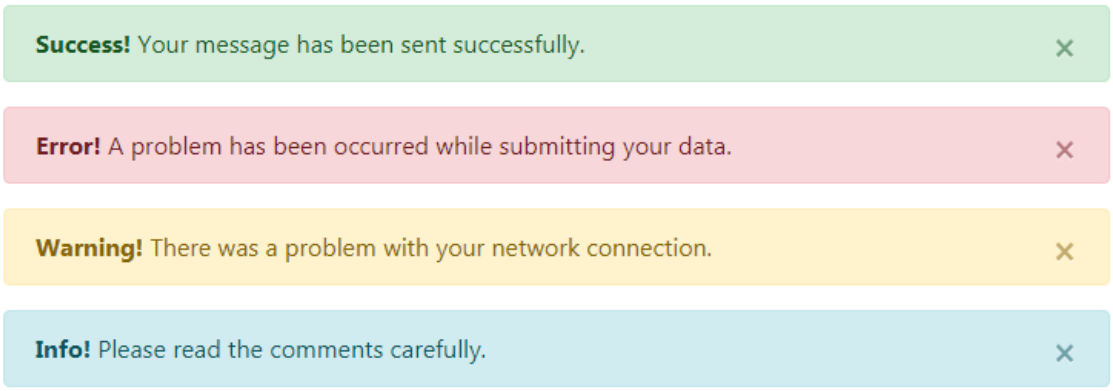


Figure 27: Bootstrap alert messages (Source: [21])

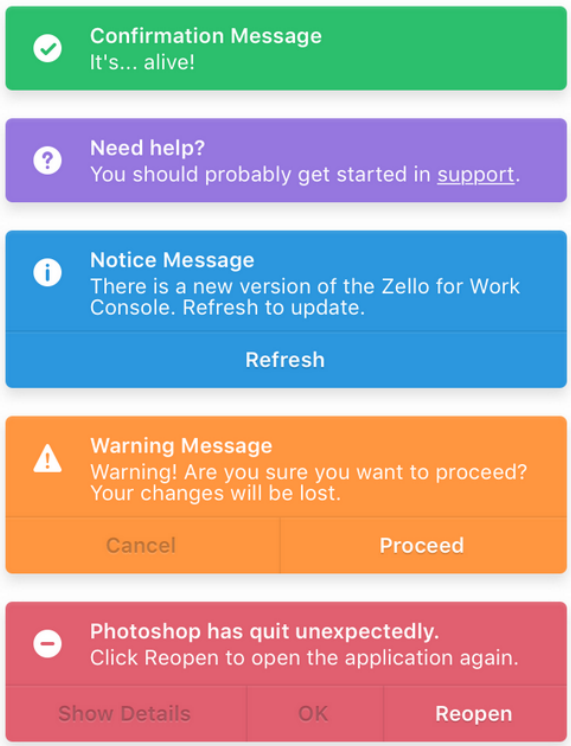


Figure 28: Example of infobar design for Android (Source: [22])

In the following chapter the author describes the possibilities of usability testing, which is closely related to the questionnaires – the main decision criteria of this work.

3 Usability testing methods

As Ana Amélia describes in her work [23], the concept of usability is related to the field of Human-Computer-Interaction (HCI). Here we can find several definitions of what usability means. In the case of websites and software applications, usability refers to whether or not users can achieve specific goals with efficiency, effectiveness, and satisfaction [24]. As pointed out by [25], the main goal of usability testing is to test and validate the product hypothesis and specific design decisions using the end-user perspective. We can come across various options for dividing usability testing methods. One possible division is nicely captured in Figure 29.

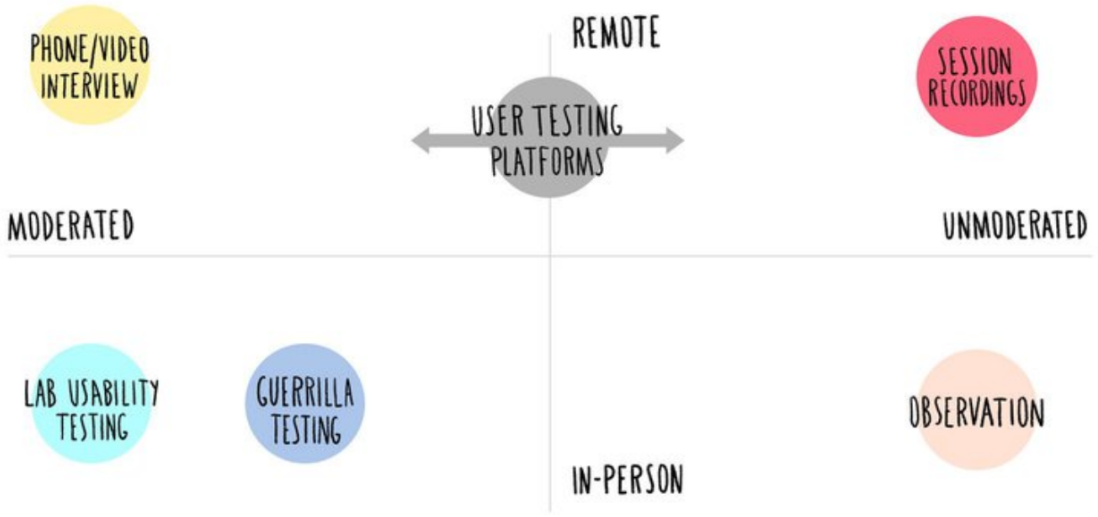


Figure 29: Usability testing methods (source: [25])

Guerrilla testing

This is the simplest form of *Moderated + in-person usability* test suitable for the early stages of the product development process. The people are asked to perform a quick usability test, often in exchange for a small gift. Test subjects are chosen at random from a public place, so that they may have no history with a product. This is the reason why Guerrilla testing is not suitable for testing products that require having special skills.

Lab usability testing

This type of *Moderated + in-person usability* research usually takes place inside a controlled environment that is different from the user's real environment. Lab usability testing works best if we need very comprehensive and detailed information about how the user works with

the program and what problems they encounter. Participants perform tasks and the researcher monitors them and asks questions. It is important that the moderator is trained and able to help participants, but at the same time, he should let them think and not tell them exactly what to do. After testing, it is also crucial to discuss and analyze the specific problems the participants have faced.

Phone interviews and Card sorting

In a phone usability test, a moderator verbally instructs participants to complete tasks on their computer and collects feedback while the user interaction is recorded remotely. This is a very good option to test users all over the world. Card sorting is a simple method that involves placing concepts or features on virtual cards and allowing participants to manipulate the cards into groups and categories. After they sort the cards, they explain their logic to a moderator.

Contextual inquiry

Sometimes also called the Interview/Observation is the *Unmoderated + in-person* usability method suitable for obtaining information about the user's habits and preferences or to evaluate whether the user is satisfied with the product. A researcher first asks a series of questions about the experience with the product and then gives the user a task to work on independently. A researcher will not provide any opinions and can only interfere if the participant gets stuck on something. Otherwise, an observer remains silent, focuses mainly on the emotions and behavior of the user, and writes notes which will be then summarized in a detailed test report.

Eye-tracking

This special method allows scientists to observe the movements of the user's eyes using a special device located on the monitor, and to create heatmaps (where the user most often looked). Eye-tracking requires a lab with special equipment and software.

Unmoderated + remote usability testing methods

Test participants are asked to complete tasks alone in their environment using their own devices. It does lead to the natural participant's behavior, however, this type of testing is less detailed. The main point is that a researcher needs to ensure that every test instruction is clear. Unclear tasks can cause results that miss the right objectives. It is not recommended to be used as a first usability testing method since it does not go deep into the user's thinking. The most commonly used online testing tools are a 5-second test and unmoderated card sorting. In the 5-second test, participants have five seconds to look at a screenshot of the page before they answer the question. Card sorting, described above, can also be conducted in an unmoderated and remote manner if a researcher leaves out the opportunity for follow-up questions.

4 Questionnaires

As the reader of this work probably realized surveys (questionnaires) were not mentioned among unmoderated + remote usability testing. The reason is that questionnaires are not usually considered as usability testing because it does not require to directly test product functionality. However, in some literature [23] [26], questionnaires are also included in usability testing methods. In Ana Amélia's work [23], for example, the survey includes both - interview and questionnaire techniques. The questionnaire refers to a technique that can fall under the so-called expert/heuristic method, which works with experienced people who identify problems a less experienced user might encounter. As the author of [26] writes, questionnaires are not as numerically grounded and precise as other forms or testing, but they can provide important feedback from the user group in a short time. They can take the form of specific questions about the software and its future development.

Questionnaires must, above all, be effective. Therefore, in this new field very different from the field of programming, it was necessary to acquire new knowledge that will help avoid beginner's mistakes. How the surveys were conceived and what they would look like eventually crystallized by combining two different information flows.

The first flow is based on what type of questionnaire is usually used if we want to examine the software usability. For this purpose, we can use the widely used standard questionnaire known as the System Usability Scale (SUS). This questionnaire having 10 five-point items with alternating positive or negative tone was introduced by Brooke in 1996 [27]. The standard version is shown in Figure 30. The aim of this work is to obtain more detailed responses from GRASS users related to a specific topic, so using this questionnaire alone does not make much sense in this work. However, the Slider questions (see 4.1) are technically realized similarly as questions in SUS - the interviewer does not evaluate questions but statements. It can often happen that the user would not use the queried functionality, but they assume that the others do, which results in a positive answer. Statements encourage the user to better express their own opinions.

The second source that inspired the author in composing the questionnaires was a user survey workshop within the All Things Open platform in which the author participated. The visited video conference[7] led by professionals Dan Zola and Kerry Thompson from SWAY UX set out a few key rules for creating a questionnaire. According to the lecturers, the questionnaire helps with the evaluation of customer satisfaction as well as understanding who are users and what are their pain points and priorities. It may be conducted not only at the start of the new project but basically, at any time the survey administrator (developer) needs user input.

[7] https://2020.allthingsopen.org/sessions/user-experience-secrets-to-better-surveys-happier-users/

System Usability Scale Questionnaire	Strongly Disagree				Strongly Agree
1. I think that I would like to use this product frequently.	1	2	3	4	5
2. I found the product unnecessarily complex.	1	2	3	4	5
3. I thought the product was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this product.	1	2	3	4	5
5. I found the various functions in the product were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in this product.	1	2	3	4	5
7. I imagine that most people would learn to use this product very quickly.	1	2	3	4	5
8. I found the product very awkward to use.	1	2	3	4	5
9. I felt very confident using the product.	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this product.	1	2	3	4	5

Figure 30: System Usability Scale Questionnaire (SUS) (Source: [27])

In order to understand what makes up a good questionnaire, it is first necessary to clarify what constitutes a bad questionnaire. The workshop summarized the following 8 errors in particular:

- Too many questions (max 10 questions)
- Convoluted questions
- Answer choices that do not correspond with user's reasoning
- Question that requires long and comprehensive answers (if open-ended questions, always put them at the beginning)
- Answers that could have more than one meaning
- Answers that do not provide any information

- Straight line answers
- Vague answers (scale from 1-10, where an answer is 5)

The latter vague answers can occur in the case of answers with a rating scale. Although the authors of the workshop do not explicitly mention the SUS questionnaire, they strongly recommend avoiding the rating scale. The result could look similar to the following example in Figure 31. It is much more advantageous to use either binary answers (Yes / No) or rank specific features.

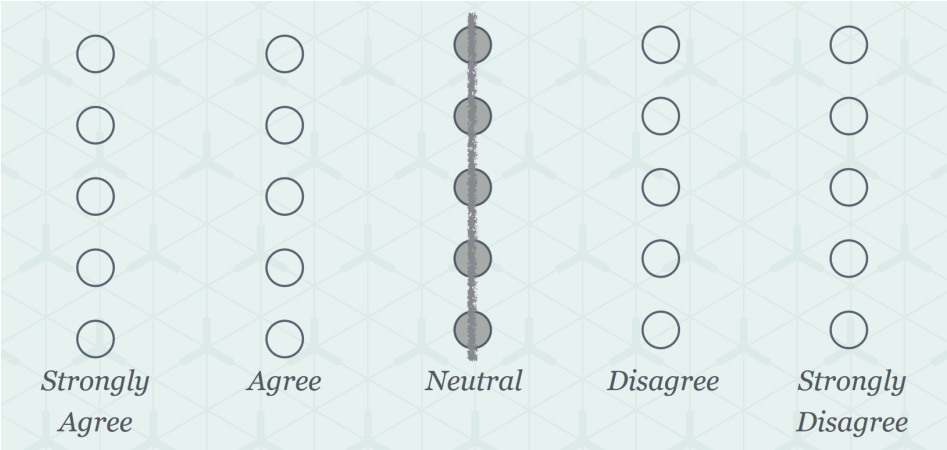


Figure 31: Difficult interpretation of the rating scale answers (source: danzolakerrythompson)

As mentioned at the beginning of the chapter, questionnaires are not usually considered as usability testing because it does not require to test product functionality. However, it would be very challenging (if not impossible) in our work to ensure users having both versions of GRASS GIS (version 7.8 and version 7.9 after GSoC) and perform usability testing in the form of Lab usability testing or Contextual inquiry methods (see section 3). **Therefore, it was finally decided to use questionnaires as the main testing method.**

4.1 Types of questions

The author followed the advice to avoid rating scale questions. Instead, she used Slider and Ranking methods, which unfortunately are not offered by the free Google Forms service but only by the paid Survey Monkey (SM) service that was eventually used. The complete list of question types offered by the Survey Monkey platform can be seen in Figure 32. Those marked in green are used in surveys in this work. The following lines will shed light on the advantages of the types used and the procedure of processing them.

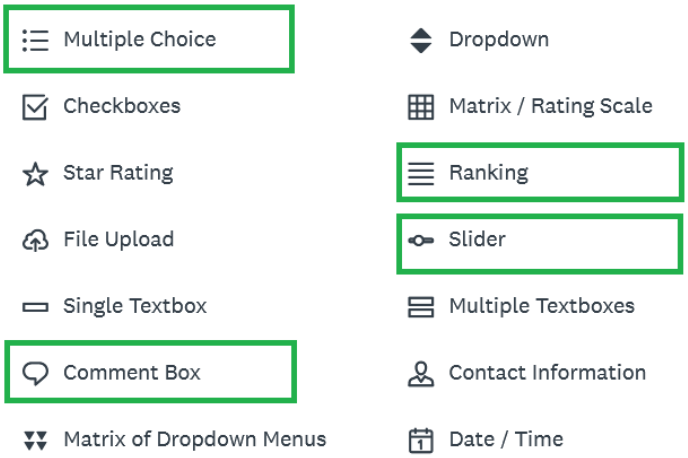


Figure 32: Survey Monkey question types (Source: Personal collection)

Slider

This type of question, also called Visual Analog Scale (VAS), can be used instead of a rating scale. We let respondents rate an item or statement on a numerical scale by dragging an interactive slider. This method is visually more pleasant than the so-called Likert scale, which is the scale used in SUS. Besides, it best captures the true opinion and perception of users, as there is no limited LS 'discrete set of predetermined responses. Sliders are, for example, widely used by healthcare professionals to determine their patient's pain. The pain does not have discrete jumps, but it is continuous, so it is appropriate to express it on a continuous scale from 0 to 100. As Matevž Pesek, Alja Isakovic [28] concluded the Slider (they call it Stripe) increases the intuitiveness, simplicity, and speed of answering the question. Therefore, this method is widely represented in the surveys conducted in this work. The form of the questions is inspired by the SUS questionnaire, in which users do not essentially evaluate the question, but try to express a degree of agreement with the opinion. A typical example of a Slider question can be seen in Figure 33.

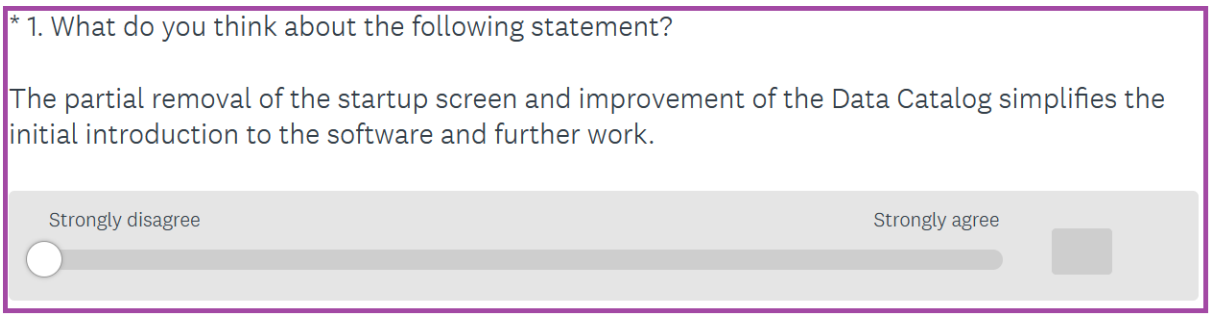


Figure 33: A typical example of a Slider question (Source: Personal collection)

Ranking

Ranking questions require the respondent to compare items to each other by placing them in order of preference. Although ranking answers usually have clear answers (the result cannot be an ambiguous answer somewhere in the middle as with the rating scale), it also has its disadvantages. It forces respondents to decide between items that they may perceive the same. It is also essential for this type of question to follow the general principle that the order of the individual options is generated randomly. Otherwise, items earlier in the list may be more likely to be ranked highest. A typical example of a Ranking question is provided in Figure 34.

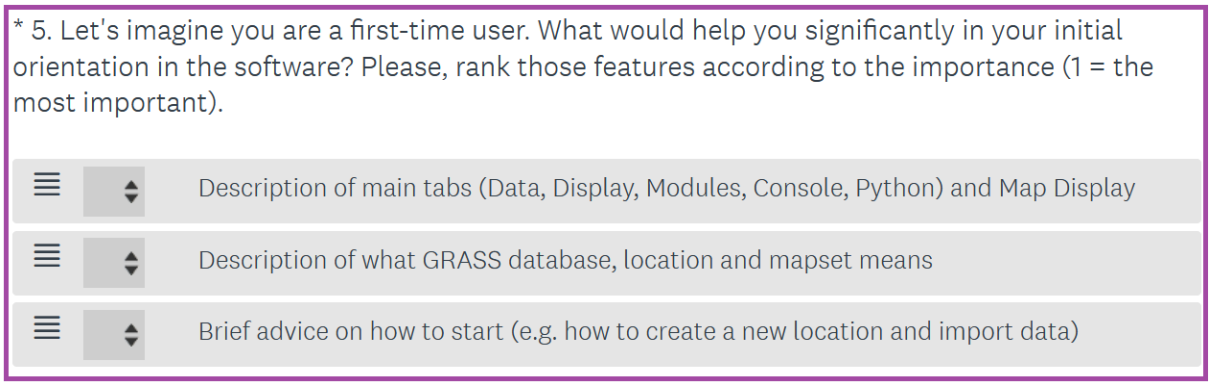


Figure 34: A typical example of a Ranking question (Source: Personal collection)

Comment Box

This more sophisticated technique in terms of subsequent analyzes allows the user to share their own ideas in the form of open-ended responses. The basis of the analysis is to determine the topics into which the answers can be categorized. It may happen that one answer includes more topics. In this case, it is advantageous to divide the answers into atomic parts and then categorize them. Comment Box questions (see Figure 35) can be further analyzed in a similar way as Multiple Choice types - by displaying the numbers of responses in individual topics using bar charts.

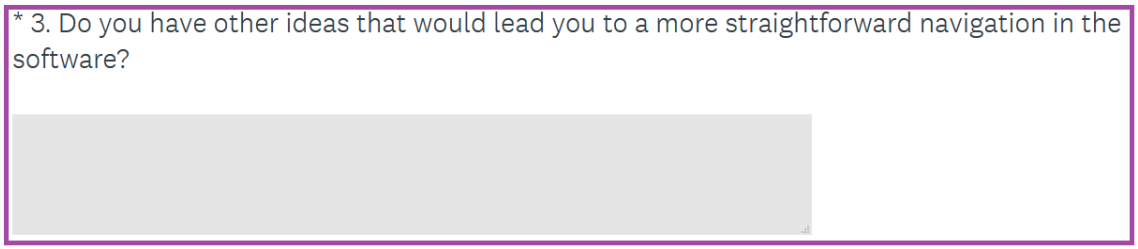


Figure 35: A typical example of a Comment Box question (Source: Personal collection)

Multiple Choice

For this type of question, we also distinguish whether the respondent can choose just one option or may check more than one. In this work, "One option" variant is used (see Figure 36). The disadvantage of the Multiple Choice question is the fact that we give the respondent a fixed list of answer options, which can skew the answers. Therefore, the "Other (please specify)" variant is usually added as the last place, which allows the user to write their own opinion. The analysis of a question providing the "Other" variant is more demanding and requires a similar approach as the Comment Box question since it has the character of an open-ended question. Therefore, the responses must first be organized into topics they deal with. If many people take the opportunity to write their own comments, it is likely that the responses to the question were not designed correctly. Then the assignment of open-ended responses to those originally set is more challenging and the telling value of responses is weakened.

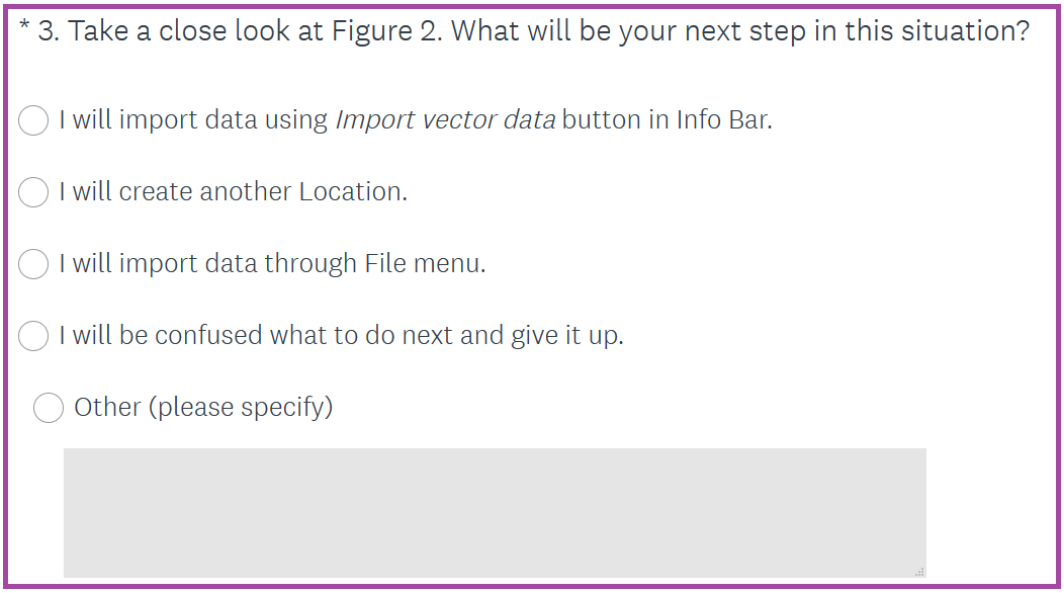


Figure 36: A typical example of a Multiple Choice question (Source: Personal collection)

4.2 Methods of questionnaire analysis

In this work, a statistical analysis of questions is performed, which uses the basic methods of Explanatory Data Analysis. Thanks to this analysis, we can discover patterns or anomalies that occur and draw the conclusions of the surveys. It is important to understand EDA as a process that does not have given rules, it only depends on the analyst which of the methods to use. As this work is purely about finding out the basic features and characteristics of a relatively small sample of answers, which counts a maximum of 52 respondents (the number of respondents

in the first part of the first survey), we analyze data over a single variable/column from a dataset. Therefore, we use only basic methods such as histograms, boxplots, and probability density functions. Other EDA tools, for example, quantile-quantile (q-q) plots, scatter plots or correlation matrices detect relationships between two or more variables. Descriptive statistics, which provides us with a brief summary of the data in the sense of Mean, Standard Deviation, and 5 elements of the box-and-whisker plot (Minimum, Maximum, 25th percentile, median, and 75th percentile), is also often considered as a part of EDA [29] [30]. In this work Ranking and Slider questions are analyzed using R language using RStudio. Here the author has applied extensive experience with this program, especially with the Tidyverse library, which is the core of data analysis in R and itself contains several interesting packages. In this work, the *dplyr* package is used for data manipulation. The visualization is made through the *ggplot2* [8] package. In addition to the R language, the Python language has become the giant of data analysis with its Pandas library in recent years.

Box-and-whisker plot

This graphical method summarizes maximum and minimum values in data, the interquartile range, and the median. It is very practical since all of those statistics can be seen at a glance. The graphical representation of individual parts of the graph is captured in Figure 37. The central box is enclosed by two lines corresponding to Q1 and Q3. A line (or whisker) that extends from each edge of the box, goes to the farthest non-outlier point in the distribution. Outliers are points that fall more than 1.5 times the IQR from either edge of the box. Usually, they are plotted individually.

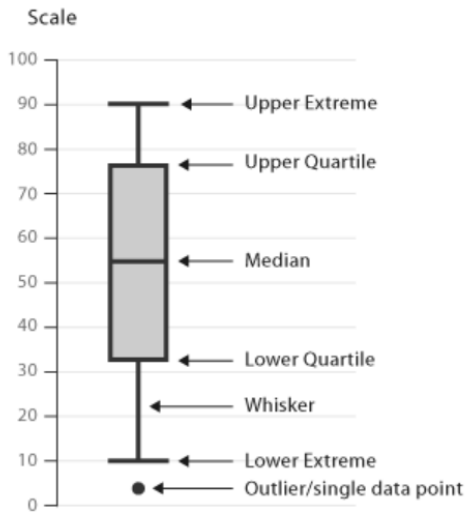


Figure 37: Description of box-and-whisker plot (boxplot) (Source: [29])

[8] https://github.com/rstudio/cheatsheets/blob/master/data-visualization-2.1.pdf

We can identify symmetry or skewness of a distribution from a boxplot. And if more than one boxplot is plotted on the same scale, we can visually compare the centers, the spreads, and the extreme values of different variables.

Histogram vs. Bar Chart

A histogram is used when working with quantitative data. It shows the number of observations that lie in-between the range of values, which is known as a bin. Unlike a bar chart, individual columns touch. Categorical features cannot be visualized through histograms. Instead, we can use bar charts where elements are taken as individual entities, so we can e.g. rearrange the blocks, from highest to lowest [31]. Illustrative comparison of Histogram and Bar Chart is shown in the following Figure 38:

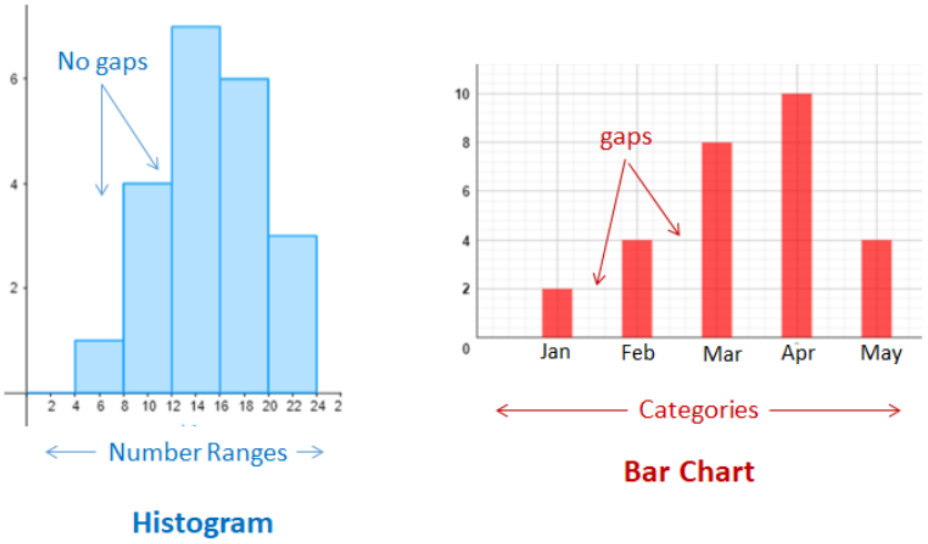


Figure 38: Histogram vs. Bar Chart (Source: [31])

Probability density function (PDF)

Simply said the Probability density curve is the graphical representation of the probability that a continuous random variable falls in a particular class. Therefore, the total area under an entire density curve is 100 %. The probability that a continuous random variable acquires a certain (exactly given) value is zero.

For a discrete random variable, we determine the probability that it is equal to exactly some value. Such a function is called the Probability mass function (PMF). It holds that all probabilities in the function must be non-negative and together give the sum of 1.

4.2.1 Data types

The analysis of survey responses depends on their type. We divide two data types - qualitative and quantitative. Qualitative data can be further divided into binary (yes / no), nominal (contains more categories) and ordinal (also contains more categories and can be sorted) [**?**]. For example, very hot, hot, cold, very cold, warm are all nominal data when considered individually. But when placed on a scale and arranged in a given order (very hot, hot, warm, cold, very cold), they are regarded as ordinal data. Regarding descriptive statistics, we can count and determine a mode (the most common value in a dataset) for nominal data. Measures of central tendency for ordinal data, in which values are ranked relative to each other but are not measured absolutely, are limited to a mode or median [32].

Examples of nominal qualitative data are the responses to questions of Multiple Choice type. Here, it is possible to create a bar chart (where we can find the mode), but other descriptive statistics do not make sense. An example of ordinal qualitative data is the responses to questions of Ranking type. A bar chart can also be compiled for Ranking questions, but the mean and standard deviation do not make sense. Ordinal variables are not continuous variables and should not be treated as if they are. Therefore, we should correctly create the Probability mass function (PMF) for Ranking questions where we determine a specific point probability on the y-axis that the discrete random variable is equal to some order. However, in question Q3 in the first part of the first survey and Q5 in the second part of the survey, PDF charts were eventually used. Although their use is not entirely correct, they provide better visual insight into the data than PMF, especially if we have several PDF charts for different variables.

Conversely, quantitative or numerical data can be characterized by a numerical value. Quantitative variables can be further classified as either discrete (those with a finite or countable number of possible values) or continuous (those with an infinite or uncountable number of possibilities) [33]. In the case of surveys conducted in this work, the Slider questions always have the same form - we measure the degree of agreement with the statement on a scale from 0 to 100. It is not a discrete variable, because we do not have any obvious categories from the beginning. Those classes have to be created. In this work, they were determined according to the SUS questionnaire: [0, 20] - Strongly disagree, (20, 40] - Disagree, (40, 60] - Neutral, (60, 80] - Agree and (80, 100] - Strongly agree.

5 Analysis of the first questionnaire

The main part of this work consists of two questionnaires. The first questionnaire was released on 23 October and stopped on 29 October 2020. It has two separate parts. The first one contains six questions dealing with the improvement of the GRASS GIS startup mechanism and the assessment of the state after GSoC. The second part of the questionnaire which is even more important for this master thesis contains 5 questions focusing on the enhancement of the newcomers' experience. In other words, it focuses on the possibilities of how to enrich the existing "demolocation" concept so that the new users can find their way around the software as quickly and conveniently as possible. The implementation part of this work is based on Survey 1 Part 2 and then especially on the second survey, which was released roughly a month later and is analyzed in Section 7.

5.1 Part 1: GRASS startup and Data Catalog

The first part of the survey called **Help improve GRASS GIS startup mechanism and Data Catalog** (see Appendix A) returns to the changes that were implemented within the GSoC. It tries both – to get feedback from users and to answer questions that remain unanswered. From this point of view, the most fundamental question is No. 2, which finds out the preferences regarding the way of starting GRASS GIS in a situation where the last mapset is not in a usable state. Questions 4, 5, and 6 are also related to the further direction of GRASS GIS (not only in terms of the startup mechanism) while questions 1 and 3 assess the benefits of GSoC. The first part of the survey was attended by 52 respondents, the completion rate was high - 96 % and no respondent skipped any questions. We can see a weekly graph of the number of responses for a specific day in Figure 53.

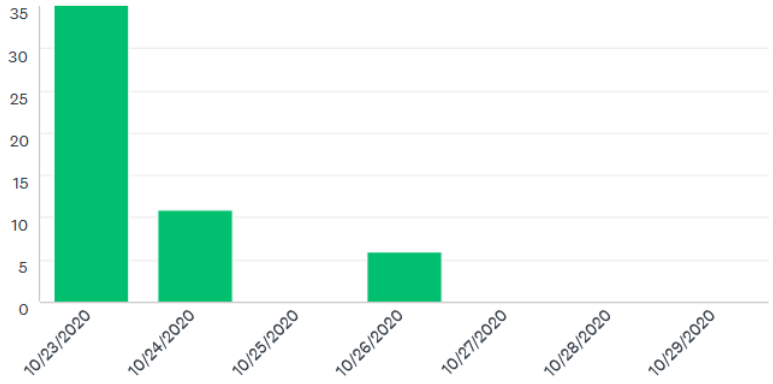


Figure 39: Survey 1 Part 1: Responses by day (Source: Basic analyzes provided by the SM)

Question 1: What do you think about the following statement?
The partial removal of the startup screen and improvement of the Data Catalog simplifies the initial introduction to the software and further work.

This question has the form of a Slider where 0 means complete disagreement with the statement and 100 means complete agreement. If we only worked with an average value of 70.9, we would conclude that enthusiasm probably prevails, but it is not so certain. The box-whisker-plot in Figure 41 shows that the median is significantly higher - 78.5 points out of a 100. If we look at the histogram in Figure 40, which was divided into 5 parts exactly according to the number of bins in the original SUS, we can see that in the last interval "Strongly agree" there are 22 responses out of 52. On this basis, we can conclude then that the vast majority like the situation after GSoC, however, there is also a minority of negative opinions.

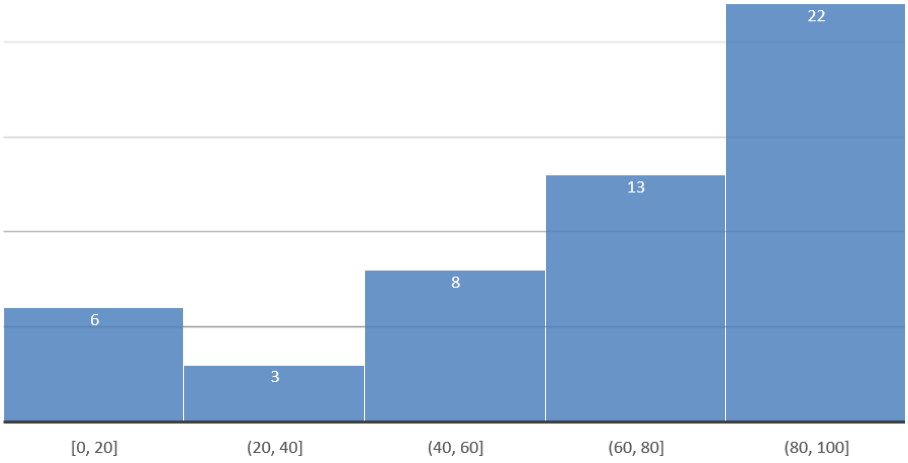


Figure 40: Survey 1 Part 1 Question 1: Histogram (Source: Personal collection)

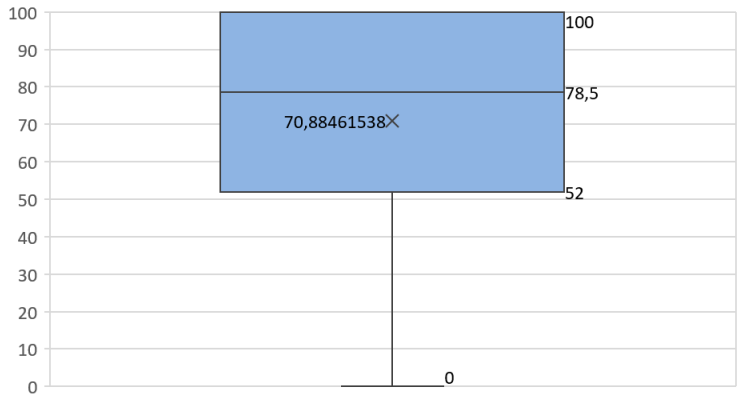
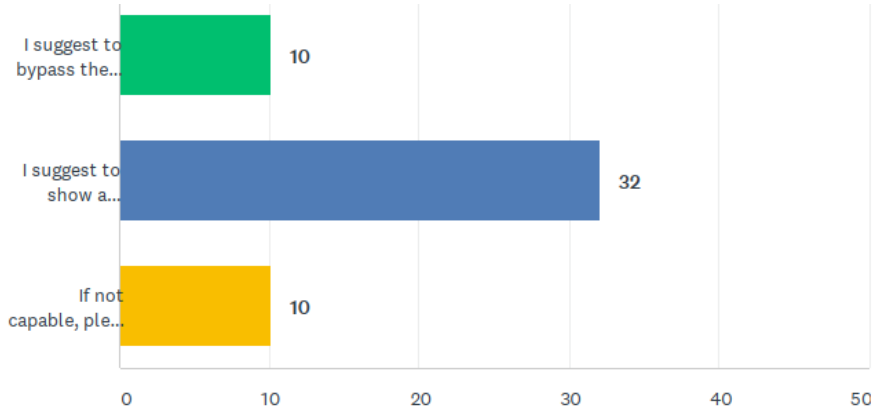


Figure 41: Survey 1 Part 1 Question 1: Boxplot (Source: Personal collection)

Question 2: How do you think GRASS should start when the last mapset is not in a usable state (was deleted or is in use)?

The result of this question put in the Multiple Choice form with the possibility of open-ended responses is very unexpected and unclear. Some open-ended answers strongly suggest that respondents did not understand from the previous context to the question (see Appendix A, page 2) that the startup screen will not be visible at all in other cases. Another drawback is the only two close-ended choices. Most people, therefore, preferred something familiar (startup screen) to the new concept of Demolocation.

One of the ways to proceed here is not to give to the result of this question in terms of the bar chart in Figure 42, as the possibilities of answers to this question were not well-conceived, and focus mainly on open-ended responses. Ten respondents choose neither of the two questions offered and took the opportunity to write their own proposal. Of the ten answers, which are categorized in the table in Figure 43, only one respondent #31 is for maintaining the original startup screen. There are some ideas of displaying a simple dialog in the form of a warning message, which offers a user some other options – e.g. to open a demolocation, an existing mapset, or to create a new mapset. There was also a suggestion that it would not be a dialog, but only a pop-up message.



ANSWER CHOICES	RESPONSES	
I suggest to bypass the startup screen and start in Demolocation.	19.23%	10
I suggest to show a modernized version of the startup screen in this situation.	61.54%	32
If not capable, please share your own idea:	19.23%	10
TOTAL		52

Figure 42: Survey 1 Part 1 Question 2: Bar Chart (Source: Basic analyzes provided by the SM)

Respondent	Response Date	Response	Response Type
7	Oct 26 2020 11:07 AM	Either in demo location or with a popup message saying the last used mapset is not available, hence opening in first location/mapset in the grassdata	Info Message
50	Oct 23 2020 01:00 PM	Warning is should be given.	Warning message
42	Oct 23 2020 02:24 PM	It should prompt the error and afterwards, with a timer, default to the a default mapset or a clean one	Error Message
13	Oct 24 2020 02:23 PM	I suggest to bypass the startup screen (as it is gone anyway), show an error and let the user either exit or offer to start in Demolocation.	Error Message, bypass the startup screen
37	Oct 23 2020 04:22 PM	Bypass the startup and start in world lat long location with basemaps	Bypass the startup screen
43	Oct 23 2020 02:00 PM	If it is easy to change the location or mapset once already within the new DataCatalog, I would suggest to bypass the startup screen and start in Demolocation. Then, if the user wants, it can create a new location or change to another location. If this is not easy (for newcomers), then I would suggest a modernized version of the startup screen.	Bypass the startup screen
31	Oct 23 2020 04:43 PM	I like it the way it is	Original startup screen
52	Oct 23 2020 12:09 PM	Shows an empty data catalog with a dialog in front: Last used maps is not accessible. Please select one of the following options: - create new one at ... - select other existing one... (could possibly combined with previous one) - quit	New simple startup screen
14	Oct 24 2020 11:23 AM	Guide the user to create a permanent area - basically, guide the user as if s/he was a new user and needed to know and create the essentials that GRASS need to start functioning.	Some kind of guide
27	Oct 23 2020 08:10 PM	What if the user deletes the demolocation? Is it created 'on the fly'? Also, the startup screen has some interesting information to the new user (what is a location / mapset). So maybe a wizard that creates the demolocation and explains what is a database / location / mapset would be interesting. That wizard could also have an option for advanced users to skip the intro and choose the correct location/mapset	

Figure 43: Survey 1 Part 1 Question 2: Classification of open-ended responses (Source: Personal collection)

The first option, therefore, how this case could be solved would be to use the infobar, which would not have an informative character (as with the proposed solution for first-time users in the second questionnaire), but would have the character of a warning. This Warning infobar explains why the user was redirected to Demolocation and instructs the user to open their own project.

The second solution is to create a simple startup screen, very similar to Moritz Lennert's Proposal B1[9], which explains the situation to the user (the last mapset used has been deleted or is in use by another process) and suggests further steps.

The advantage of changes made after GSoC is that changing the database, location or mapset is very simple through the new Data Catalog, as well as saving and opening workspaces. Therefore, not only the author but also other developers are inclined rather to the variant to completely remove any form of startup screen and employ infobars instead.

Question 3: Please, rank how useful these features in Data Catalog would be (or already are) for you (1 = the most useful).

This question asks the GRASS user to evaluate the benefits of the new features that were introduced after GSoC (see Figure 8) . The implementation of *Small icons distinctive mapping, locations, GRASS databases, and layers (vector, raster)* is the work of Anna Petrasova, other functions are part of the implementations performed by the author. The evaluation of functions is performed by sorting them from the most useful (number 1) to the least useful (number 7).

According to the means in Figure 44 the greatest success have *New management icons*. However, the use of mean and standard deviation is quite misleading for ordinal types of variables. It is better to focus on the median whose values are in Figure 44 marked in a red box. The median is the smallest for *Small icons distinguishing mapsets, locations, GRASS databases, and layers (vector, raster)*. Although the responses do not have the character of a continuous random variable and the Figure 47 is somewhat misleading in terms of statistics, *Small icons distinguishing mapsets, locations, GRASS databases, and layers (vector, raster)* are also the most successful here. In the second place, there are *New management icons* and in third place, we can find *Creating, renaming and deleting mapset or location*.

Interestingly, no special success was achieved by *Adding multiple GRASS databases*, which were relatively difficult to implement. As can be seen from the stacked bar chart in Figure 45 and also the boxplot in Figure 46, the most controversial is *Mapset access info (current, in use, and a different user)*, which some users rated as the most useful and a similar number of users as the least useful.

[9] https://trac.osgeo.org/grass/wiki/wxGUIDevelopment/New_Startup#Changeparadigm

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
New management icons for adding GRASS database, location, and mapset, and for downloading location	1.00	7.00	3.00	2.96	1.70
Creating, renaming and deleting mapset or location	1.00	6.00	3.00	3.15	1.47
Small icons distinguishing mapsets, locations, GRASS databases, and layers (vector, raster)	1.00	7.00	2.50	3.27	1.89
Mapset access info (current, in use, and a different user)	1.00	7.00	4.00	3.83	2.21
Deleting multiple mapsets or locations	1.00	7.00	5.00	4.63	1.65
Adding multiple GRASS databases	1.00	7.00	5.00	4.67	1.70
Removing GRASS database from Data Catalog / Deleting GRASS database from disk	1.00	7.00	6.00	5.48	1.87

Figure 44: Survey 1 Part 1 Question 3: Descriptive statistics (Source: Basic analyzes provided by the SM)

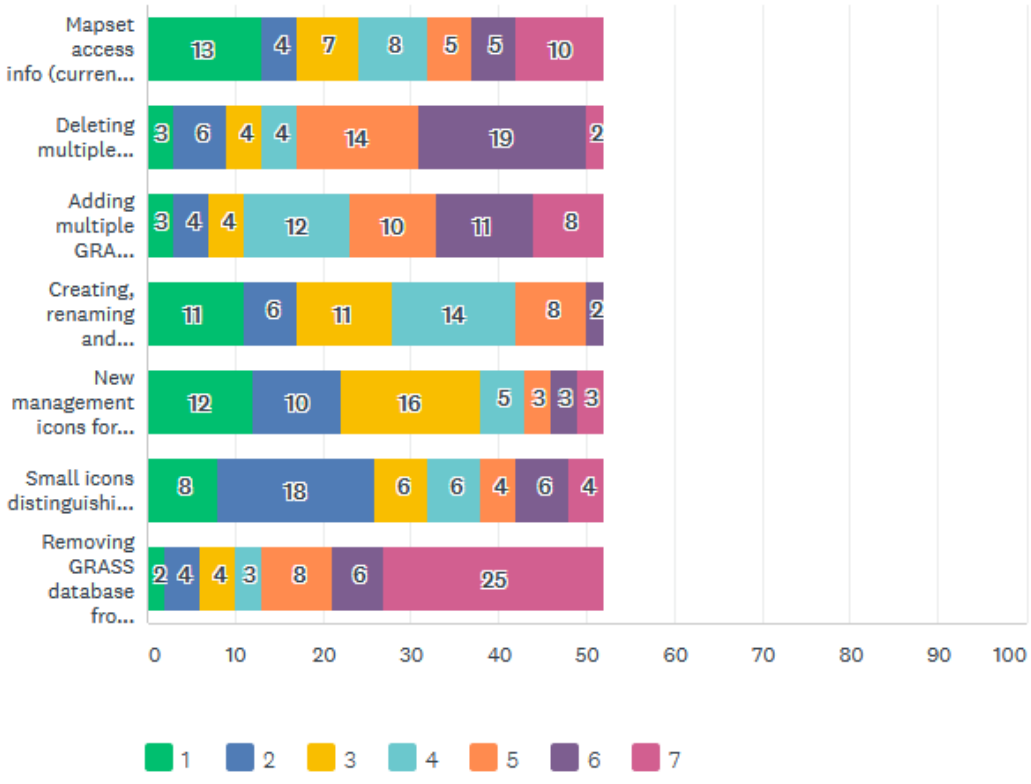


Figure 45: Survey 1 Part 1 Question 3: Stacked Bar Chart (Source: Basic analyzes provided by the SM)

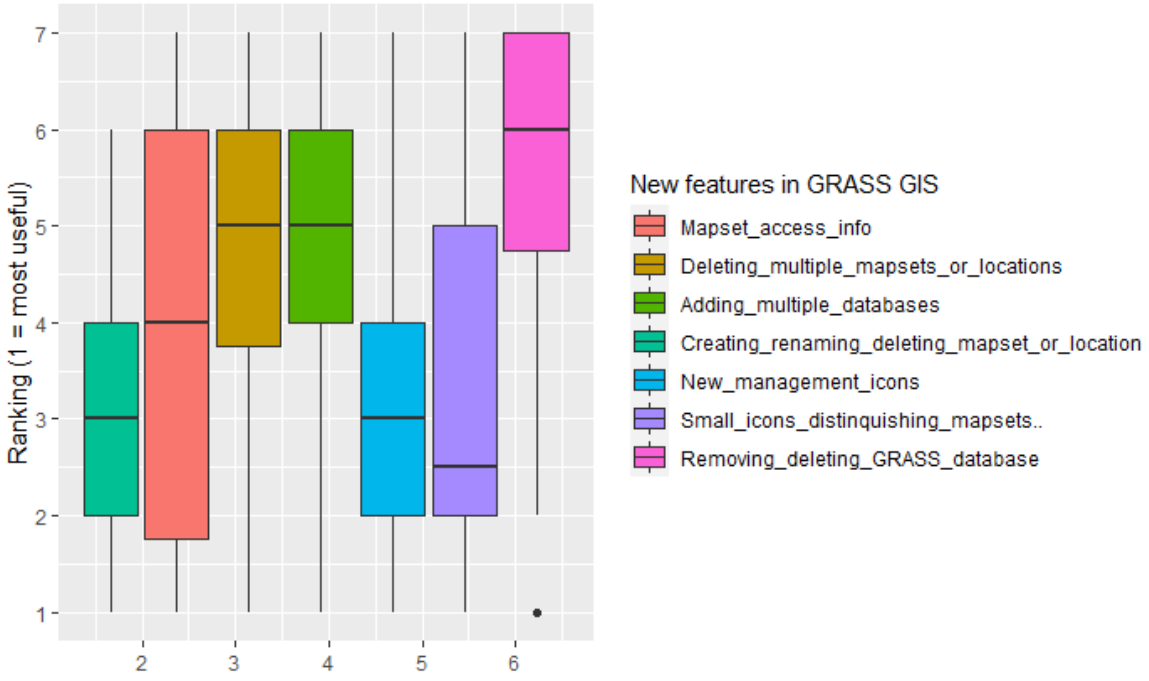


Figure 46: Survey 1 Part 1 Question 3: Boxplot (Source: Personal collection - R analysis)

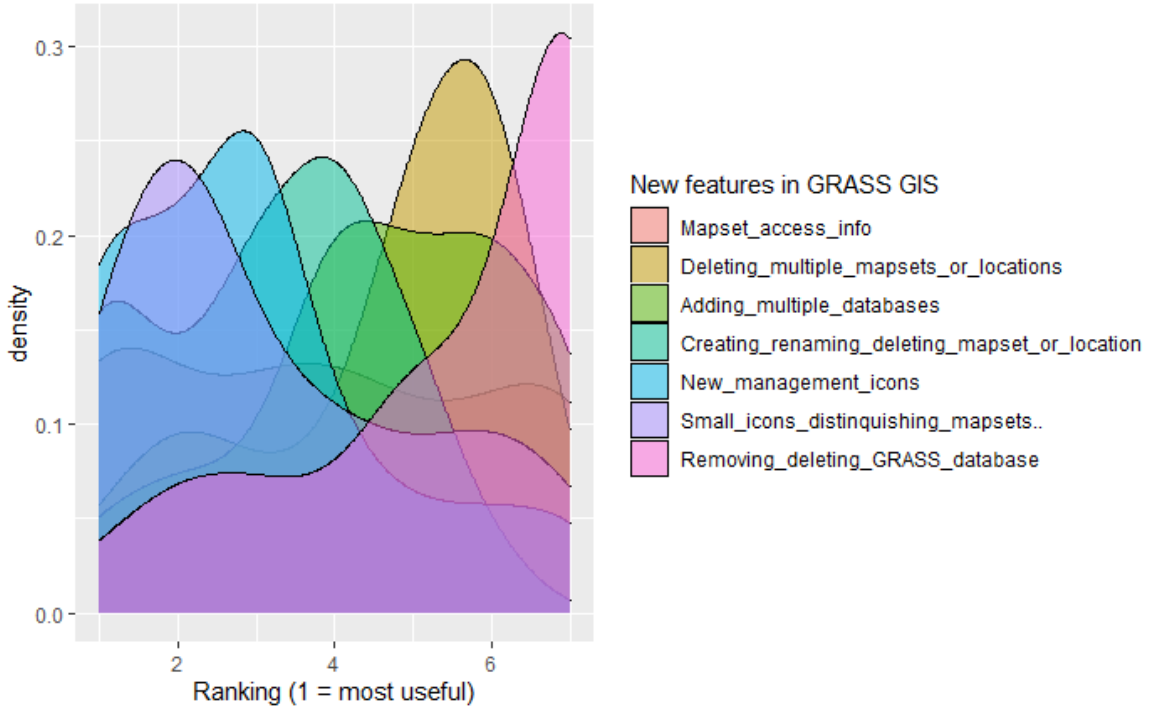


Figure 47: Survey 1 Part 1 Question 3: Probability Density Function (Source: Personal collection - R analysis)

Question 4: Which features would you like to add?

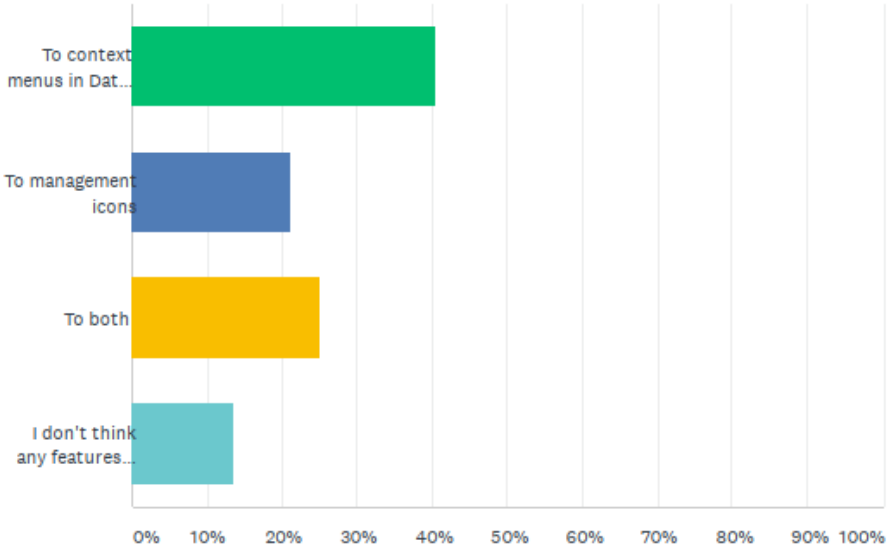
From the point of view of the Data Catalog, in Figure 48, we can see proposals for the EPSG code shown after the location name, cloning the location, deleting multiple layers via the context menu, displaying space-time datasets (STDS), or displaying saved workspaces. Regarding things unrelated to the Data Catalog, three users would like an easier and clearer way to add WMS/WFS using a new icon.

Selected Respondents	Response Date	Responses	Type
3	Oct 26 2020 03:40 PM	A new management icon for region settings	Data tab - Management icons
5	Oct 26 2020 12:43 PM	filtering of maps shown in list	Data tab - Data Catalog
7	Oct 26 2020 11:07 AM	Zoomtolayer in context menu	Data tab - Data Catalog
27	Oct 23 2020 08:10 PM	Easily move items between mapsets / locations?	Data tab - Data Catalog
41	Oct 23 2020 02:42 PM	The EPSG code in parenthesis just after the location name	Data tab - Data Catalog
44	Oct 23 2020 01:53 PM	Show mapset EPSG next to the mapset's name in the catalog (or at least be able to toggle that information on/off, default off)	Data tab - Data Catalog
46	Oct 23 2020 01:47 PM	Delete more than one layer via context menu	Data tab - Data Catalog
47	Oct 23 2020 01:37 PM	Cloning a location	Data tab - Data Catalog
48	Oct 23 2020 01:28 PM	I would like to see space time datasets - STDS listed too (and when clicking on the STDS name see the maps registered within them). Also, I would like to see saved workspaces somewhere in the data catalog.	Data tab - Data Catalog
16	Oct 24 2020 10:02 AM	More friendly layers-coloring, ie accessible from the layer tree already (rather than via accessing a function)	Display tab - Layer Tree
1	Oct 29 2020 07:18 AM	Drag and drop vector/raster layer(s) into map window.	Map Display
33	Oct 23 2020 04:41 PM	zoom capability with mouse without messing up the window. (intuitive zoom)	Map Display
2	Oct 26 2020 04:07 PM	I may not be familiar with this feature if it already exists, but I would like to see an easier process to access WMS/WFS.	WMS button
51	Oct 23 2020 12:47 PM	Services icon	WMS button
37	Oct 23 2020 04:22 PM	Add WMS button? Streaming basemaps from WMS like stamen, mapbox, etc...	WMS button
15	Oct 24 2020 10:24 AM	ability to import and restructure projects from other gis programs	Unclassified
22	Oct 23 2020 10:45 PM	Clear link to startup help for first time users explaining map sets, regions, etc. maybe that as a startup dialog in lieu of the old dialog.	Unclassified
26	Oct 23 2020 08:14 PM	Create the Demo Location with most common web map EPSG	Unclassified
45	Oct 23 2020 01:50 PM	add some fun "easter egg" tricks, like QGIS has.	Unclassified
39	Oct 23 2020 03:14 PM	improve ui	Unclassified
13	Oct 24 2020 02:23 PM	How to support the use case that a user receives a GIS file and wants to create a new location from it?	Already exists (so perhaps hard to find or otherwise unknown)

Figure 48: Survey 1 Part 1 Question 4: Classification of open-ended responses (Source: Personal collection)

Question 5: Because we have limited screen space, we need to think about where we can add new features.Where would you add them?

In this Multiple Choice question analyzed in Figure 49 using the bar chart, most respondents agree to add additional functions to the context menu. Interestingly, 13.5 % of respondents think that *no additional features should be added, there is little space for them.* That is almost a seventh of the respondents, so also a relatively significant part. So there is a certain fear that the added functions may rather reduce the clarity of the current solution. This is also evidenced by the fact that in the Q4 none of the respondents mention adding more complex functions to the Data Catalog, such as Data Import. The improvements mainly concern the management of data hierarchy in GRASS.



ANSWER CHOICES	RESPONSES	
To context menus in Data Catalog	40.38%	21
To management icons	21.15%	11
To both	25.00%	13
I don't think any features should be added. There is little space for that.	13.46%	7
TOTAL		52

Figure 49: Survey 1 Part 1 Question 5: Bar Chart (Source: Basic analyzes provided by the SM)

Question 6: So, what do you think about the following statement? I would start GRASS using the file association of the workspace file (.gxw) frequently.

This question takes the form of a Slider and was intentionally conceived in this somewhat strict way. It depends on the opinion of individuals whether they would really use this functionality often, not on the general belief, which can be distorted by the fact that in other software this functionality is a matter of course. Among highly evaluated proprietary and free software by GIS Geography [1] (ArcGIS Pro, Geomedia Advantage, MapInfo Professional, QGIS, gvSIG, GRASS GIS, ILWIS, SAGA GIS), GRASS GIS is the only software of mentioned together with ILWIS, that cannot be started using the file association of the workspace file. Nevertheless, based on the results, users do not seem to mind.

The author can name several reasons why. After changes within GSoC, GRASS GIS starts in the last open mapset to the Data tabs, which allows easy switching between mapsets, opening GRASS databases, saving and opening workspaces, etc. It is therefore very easy to work with the data hierarchy. In addition, the data is stored directly in the mapsets, so it is not necessary to remember where in the disk the data is located, such as in QGIS. Another reason is that GRASS GIS is often started from the command line.

The average value of the degree of agreement with the statement is 51, as you can see from Figure 50. The median is slightly higher, just over 54 points. Both of these values are more or less meaningless. The most interesting view is offered by the histogram in Figure 51 and PDF in Figure 52. The largest density values are in the range of 50 - 75, according to which we can conclude that the answer whether to implement is rather yes, but it is not a functionality that is perceived as essential.

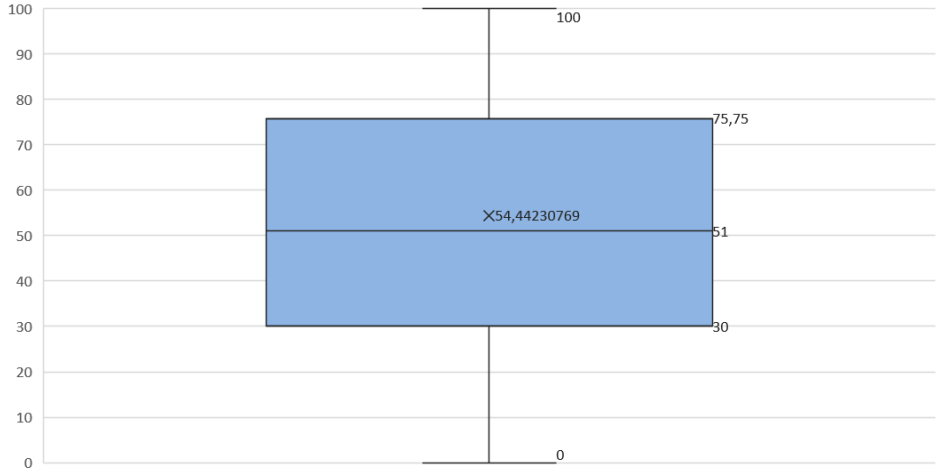


Figure 50: Survey 1 Part 1 Question 6: Boxplot (Source: Personal collection)

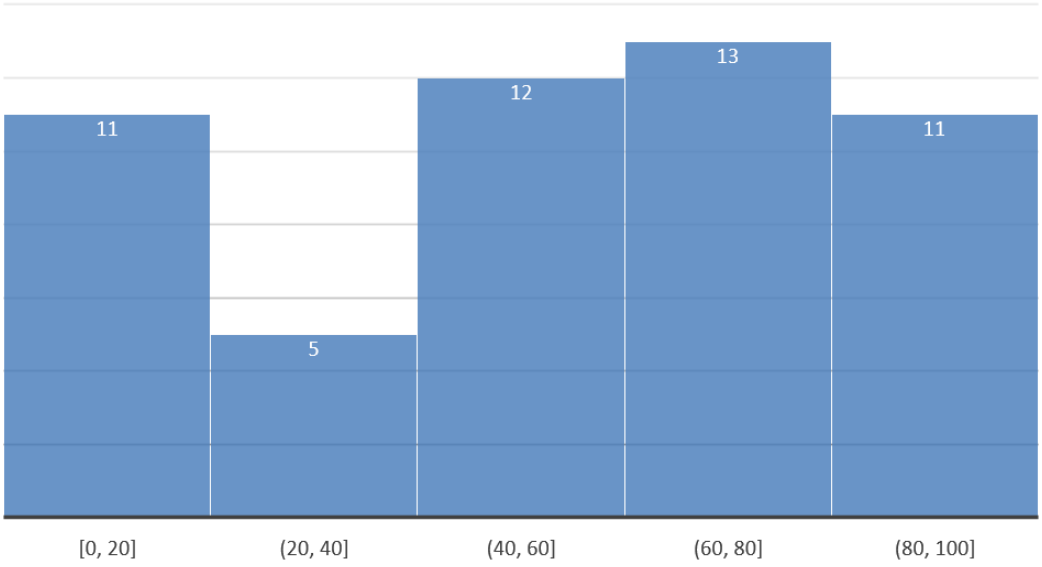


Figure 51: Survey 1 Part 1 Question 6: Histogram (Source: Personal collection)

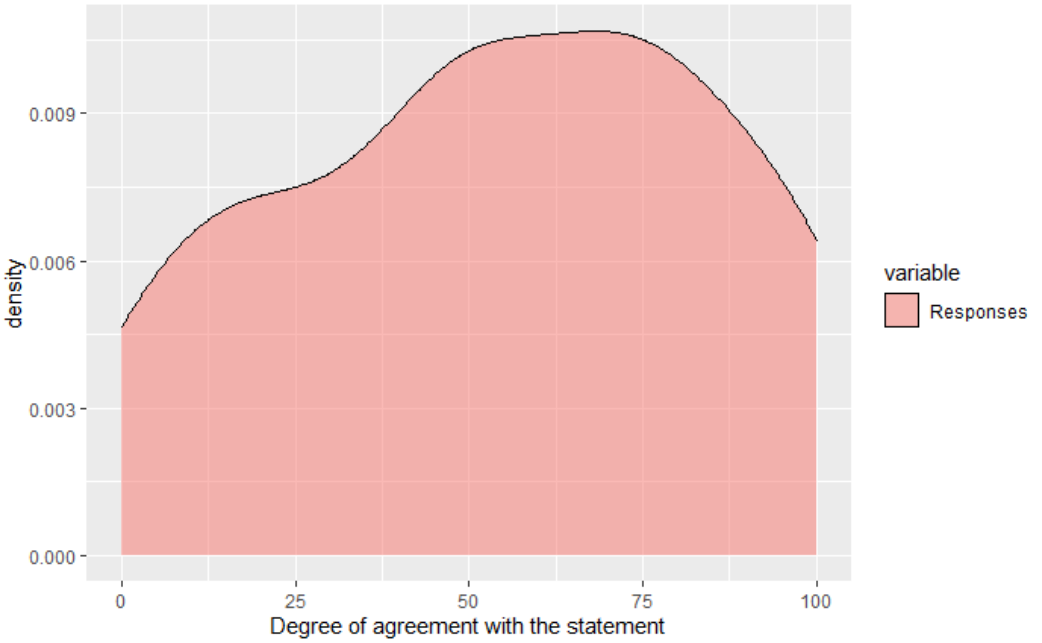


Figure 52: Survey 1 Part 1 Question 6: Probability Density Function (Source: Personal collection - R analysis)

5.2 Part 2: Better first-time user experience in GRASS

The second part of the survey called **Help create a better first-time user experience in GRASS GIS** seeks to get user preferences on how they would like to improve the first-time user experience. This survey consists mainly of Multiple Choice and Comment Box types of questions, so the evaluation is very subjective, and there are exceptional answers where the author was not entirely sure whether she understood them correctly. This is, after all, one of the disadvantages of questionnaires and remote usability testing in general.

This part of the survey offers two ways to improve the first-time user experience (see section 2). The first way uses the component of infobar (used e.g. in QGIS 3 and Matlab Simulink) while the second way represents the implementation of First Run Wizard (e.g. Zoner Photo Studio X). Respondents evaluate these topics in the first two questions, thus giving feedback on which of the above-mentioned options they would prefer in GRASS. Question 3 offers the option to write suggestions on how to improve the first-time user experience. In Question 4, users share ideas for software that is user-friendly, while in Question 5, we then find out which specific things cause problems for users and what any first-time advice should be about. The second part of the first survey was attended by 46 respondents, the completion rate was high – 97 %. Question 4, which was optional, was skipped 14 times. Other questions were answered by all participants, however, the answers were not always relevant, so not all are part of the analyses. We can see a weekly graph of the number of responses for a specific day in Figure 53.

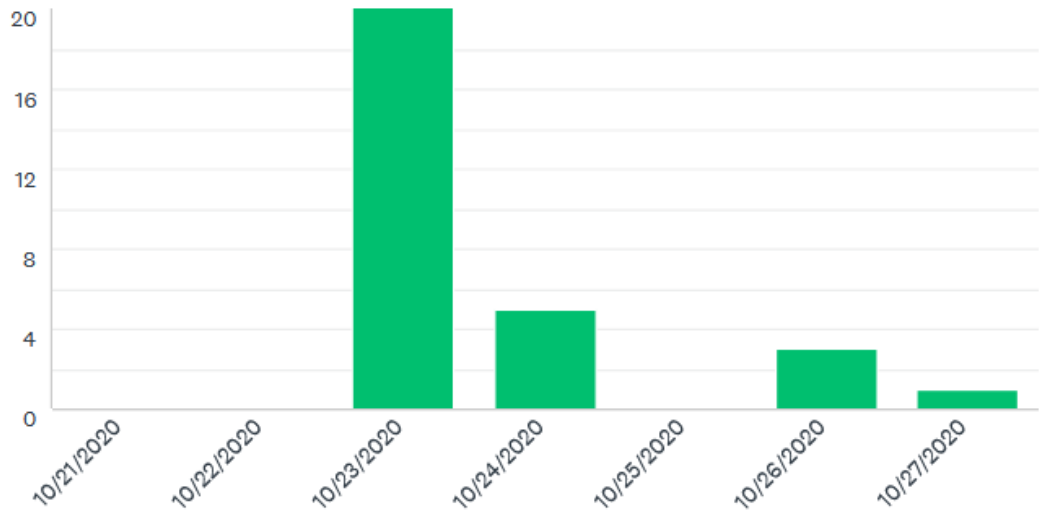
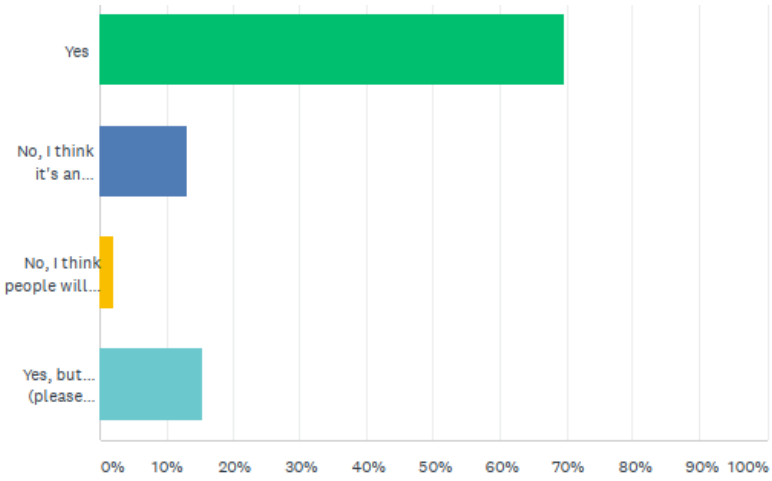


Figure 53: Survey 1 Part 2: Responses by day (Source: Basic analyzes provided by the SM)

Question 1: Do you like the idea of First Run Wizard (inspired by Zoner implementation)?

Users mostly like the idea of First Run Wizard, but there are also a lot of comments in Figure 54 highlighted in pink, which First Run Wizard finds rather annoying. After all, comments #1 and #2 also mean "No, because..." rather than "Yes, but...". If we then combine the subgroups into two large groups "Yes" and "No", we will come to the conclusion that 33 (71.7 %) respondents are for and the remaining 13 (28.3 %) respondents against First Run Wizard.



ANSWER CHOICES	RESPONSES	
Yes	69.57%	32
No, I think it's an unnecessarily complicated option	13.04%	6
No, I think people will skip it anyway	2.17%	1
Yes, but... (please specify)	15.22%	7
TOTAL		46

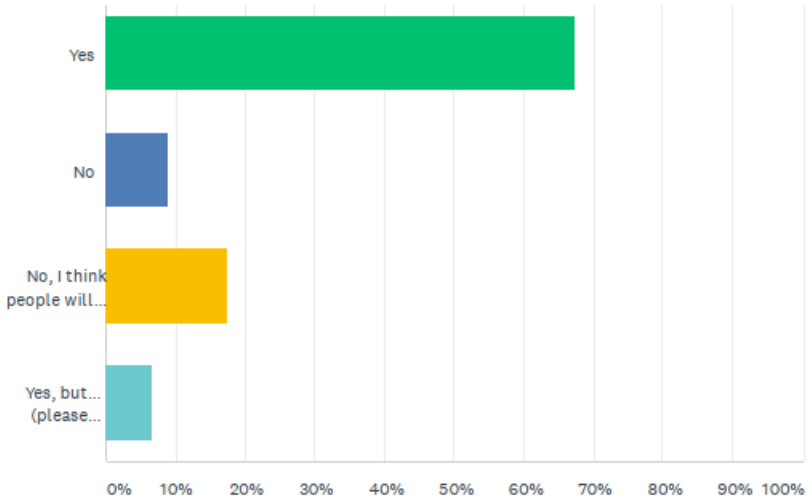
#	YES, BUT... (PLEASE SPECIFY)	DATE
1	but make the startup process as simple as QGIS. The original startup process of GRASS is way too old and complicated for new users.	10/27/2020 3:04 PM
2	In my experience, tutorials work best not when done once but when they are set up to be constantly referenced for small things. I would recommend a written and video tutorial that is linked to by these pop-ups rather than tutorial methods delivered to the user.	10/24/2020 1:41 PM
3	Explain regions and map sets and how it will affect your session, data import/export options.	10/23/2020 10:58 PM
4	No? Maybe? Could be helpful for some, but very annoying for others. Need to have a way to quickly disable / skip it.	10/23/2020 4:16 PM
5	Allow the user to skip it	10/23/2020 2:05 PM
6	there should be the option to bypass the first run wizard	10/23/2020 1:56 PM
7	but make it optional	10/23/2020 1:55 PM

Figure 54: Survey 1 Part 2 Question 1: Bar Chart, descriptive statistics and open-ended responses (Source: Basic analyzes provided by the SM)

The comment #2 recommends creating pop-ups that themselves contain only the most important information, but refer to a written or video tutorial. So, the point is to include as few distractions as possible in the software itself, but to refer well to detailed information, for example in the form of a "Learn more" button.

Question 2: Do you like the idea of the first-time mode infobars (visually similar to infobars in QGIS implementation)?

People largely like both the infobars and the First Run Wizard. However, there are fewer "Yes, but..." comments in infobars, and unlike the previous question, they are literally "Yes, but...", as we can see in Figure 55.



ANSWER CHOICES	RESPONSES	
Yes	67.39%	31
No	8.70%	4
No, I think people will ignore it	17.39%	8
Yes, but... (please specify)	6.52%	3
TOTAL		46

#	YES, BUT... (PLEASE SPECIFY)	DATE
1	additional info might be useful	10/27/2020 3:04 PM
2	Seems like it can only help. Though I would make it a manual option by the user, part of the info bar, to stop them, for the same reason as above.	10/24/2020 1:41 PM
3	Avoid certain colours like yellows and reds - users will think something is wrong	10/23/2020 2:05 PM

Figure 55: Survey 1 Part 2 Question 2: Bar Chart, descriptive statistics and classification of open-ended responses (Source: Basic analyzes provided by the SM)

A relatively large proportion of respondents (17.4 %) think that infobars will be ignored by new GRASS users. If we combine the subgroups into two main groups "Yes" and "No", we conclude that 34 (73.9 %) respondents are for and 12 (26.1 %) against infobars. This is a slightly better balance than in Question 1. But even here we must be careful. The difficult task will be to find a compromise between the fact that the information icons must be placed in the right place so that the user can ignore them as little as possible, but at the same time must not act as a warning, which is also pointed out by comment #3.

Question 3: Do you have other ideas that would lead you to more straightforward navigation in the software?

For this question, GRASS GIS users were very shared, which resulted in a very detailed analysis of the answers into 12 groups. However, the variety of responses is so wide that many responses could not be included, so they ended up in a separate "Other" group. In the following lines, the author summarizes and discusses in more detail several opinions that were expressed. The color representing categories in Figures 56, 57, 58 is purely random.

The first topic that permeates the whole questionnaire is how to better explain the GRASS GIS data hierarchy to newcomers. In this question, this topic is mentioned by respondents #2, #8, #19, #22. For example, respondent #8 suggests a "First Time Help" pop-up window that explains folders on a disk, locations, etc. However, the topic of GRASS data hierarchy appears in other questions as well. For example, in Question 4 respondent #1 talks about the old concept of location. However, as can be seen from the answers #25 and #27, some users are satisfied with the current system.

Either way, data hierarchy in GRASS is usually one of the main topics of video calls of the developer community and the only agreement is that the concept of *database/location/mapset* is abstruse to new users. The truth is that if database/location/mapset were named differently and more intuitively (for instance *database/project/subproject*) and thus closer to the standard of other free GIS software, then the word "old" would not be part of the criticism. Therefore, perhaps the most feasible proposal that will not interfere so much with the implementation of GRASS is to maintain the concept but to change the terminology.

The second important topic is better documentation, for example with the use of videos. Respondent #26 would even like very detailed PDF manuals with print screens and information on each button and functionality. It should be noted here that the proposed solutions that will improve the first-time user experience must be sustainable also in terms of further development, which will probably be crucial in the future, as the community around GRASS is very lively.

Selected Respondents	Response Date	Responses	Response Type
1	Oct 27 2020 03:04 PM	make the creation of a project simple, at the moment when users just want to see their data in a viewer, they are bogged down with projects etc. which is not necessary.	Asks for simplicity or immediately see some data
13	Oct 23 2020 09:10 PM	keep it simple as possible	
14	Oct 23 2020 08:14 PM	Don't make the first time run wizard too long.	
3	Oct 26 2020 12:42 PM	immediately show map at first startup	
		provide links to tutorial videos	Asks for videos
17	Oct 23 2020 04:44 PM	Optional video tutorials put out by GRASS GIS	
20	Oct 23 2020 04:42 PM	associated videos for guidance	
28	Oct 23 2020 01:55 PM	Creating short videos on getting started with GRASS.	
19	Oct 23 2020 04:43 PM	Something about file management, or the creation of a grass directory?	Asks for more info on db/loc/mapset
22	Oct 23 2020 03:22 PM	Navigate in grass is easy. All modules are accessible in menus, or toolboxes, etc. What is really difficult is the concept of workspace and create the locations.	
2	Oct 26 2020 03:49 PM	Description of what GRASS database, location and mapset means	
		See the Data management first and a description of the main tabs	Asks for description of main tabs
21	Oct 23 2020 04:16 PM	Changes to the GUI. Put of all GRASS into a single window (that can be rearranged), rather than multiple floating windows. Open new map displays in tabs rather than new windows.	Asks for single layout
29	Oct 23 2020 01:38 PM	What about a single window? Different map displays could be open as tabs linked to tabs in the layer manager, for example.	
10	Oct 23 2020 11:37 PM	Qgis like processing panel	Already exists (so perhaps hard to find or otherwise unknown)
11	Oct 23 2020 10:58 PM	Tool search (similar to processing interface)	
4	Oct 26 2020 11:49 AM	Nope but I am not sure that having the demolocation as default is a good idea. I think it will confuse users and take space on disk. Also I hope that with all these new functionalities the options from the command line are still available.	Asks for not having demolocation as default
8	Oct 24 2020 11:11 AM	My difficulties with GRASS were due to not easily finding out the basic needs and structure of how GRASS 'hangs together'.	Asks for more info on db/loc/mapset, Asks for brief advice on how to start

Figure 56: Survey 1 Part 2 Question 3: Classification of open-ended responses - part 1 (Source: Personal collection)

7	Oct 24 2020 01:41 PM	QGIS works as an extremely helpful facade for engaging with GRASS GIS functions. I still struggle to use many GRASS functions because GRASS uses terms that do not map to the terms used for general GIS work. Comparing the pop-up and input options for a vector function like v.distance in GRASS to it's equivalent is a good way to see the difference. GRASS's non-intuitive inputs and lingo prevent me from using most of the functions. The tutorials in my experience do no better to translate them, they simply regurgitate what's in the sidebar for the function already. Though I will be first to admit I may not have found the right tutorial page.	Asks for better lingo or doc
23	Oct 23 2020 02:33 PM	A better documentation page	
26	Oct 23 2020 02:04 PM	An alternative would be very detailed pdf manuals with the printscreens and information on each button and functionality. Something similar but not necessarily attached to the GUI. This pdf could be accessible or suggested when opening GRASS.	
8	Oct 24 2020 11:11 AM	A "First Time Help" popup which tells the user what GRASS must have before it can startup. e.g.: A folder on disk, a projection, a ???	Asks for Info Icons
9	Oct 24 2020 10:07 AM	Having a beginner checkbox(true by default), where a helper hover message appear when i put the mouse on open a new dialog	
15	Oct 23 2020 04:47 PM	info icons that would allow folks to hover and know what they're working with/link to help or FAQs	
18	Oct 23 2020 04:43 PM	specifying when a double click vs a right click leads to more info / options	
5	Oct 24 2020 04:50 PM	Maybe a pop-up for data import (with user choice if this should go into current projection or into new location)	
12	Oct 23 2020 09:28 PM	It's uncommon to start a blank gis project. Usually, when I use a GIS, I already have at least a satellite image or a shapefile. It would be great to have a First Run Wizard focused on that initial data, for setting up the project's bounding box and spatial reference system.	Asks for First Run Wizard
6	Oct 24 2020 03:11 PM	Develop a "knowledge wizard" how to address geospatial questions. Like - "I want to ... resample" --> show all commands having "resampling" as a keyword + Wiki page (https://grasswiki.osgeo.org/wiki/Interpolation#Resampling_methods_and_interpolation_in_GRASS_GIS) - "I want to clean vector topology" --> same + Wiki page - etc.	Other
16	Oct 23 2020 04:45 PM	an undo button would be nice	

Figure 57: Survey 1 Part 2 Question 3: Classification of open-ended responses - part 2 (Source: Personal collection)

24	Oct 23 2020 02:17 PM	LibreOffice as a nice implementation of different types of toolbar layout	Other
25	Oct 23 2020 02:05 PM	The Database/Locations/Mapset structure offers many advantages but it takes time to get your head around it even if you are not new to GRASS. Unfortunatelly I do not have any suggestions because changing that structure would mean, I guess, to compromise many other great features of GRASS.	
27	Oct 23 2020 01:56 PM	QGIS has a lot of capability that is lacking up-front with GRASS; BUT, I really prefer the look & feel of the GRASS GIS GUI; I find it more intuitive and logical. This is not to say improvements (added capability) should not be made, there can be, but not at the expense of current usability. I don't believe this is simply because of familiarity	

Figure 58: Survey 1 Part 2 Question 3: Classification of open-ended responses - part 3 (Source: Personal collection)

Therefore, it is advantageous to focus on smaller outputs, which is easy to edit in case of changes, rather than doing "inflexible" tutorials, whether in the form of PDFs or videos, which can be very outdated in a short time, thus for new users rather confusing. However, this does not mean that short videos or clearer documentation could not be created. Inspiration can come here from QGIS, as suggested by respondent #14 in question 5. Respondent #7 also encounters the relationship between QGIS and GRASS. GRASS modules can also be run through QGIS. However, the GRASS function in QGIS has a different description than the same module in GRASS. This should be unified on the GRASS side.

From the point of view of the further direction of this master thesis, a very important topic is how to improve the first-time user experience directly in the software, in other words how to improve demolocation where GRASS starts automatically after the first start. The answer #3 is closely related to this since it asks for immediate display of the map. After all, for example, the open-source software Blender for modeling and rendering 3D computer graphics shows the cube when started. It is therefore natural for a new GRASS user to see the map. Furthermore, the classification also shows that brief advice on how to start would be valuable for newcomers and six respondents (#5, #8, #9, #12, #15, #18) mentions some form of info icons. Respondents #5 and #12 also point out the importance of the initial data and its easy import into the GRASS GIS. Two opinions call for putting GRASS into a single window.

The answers also point out some of the problems that users face without explicitly mentioning them. Respondents #10 and #11 want a "Tool search" which is already part of the Modules tab. This may indicate that users did not understand the meaning of other tabs (probably did not notice them). By the way, Question 5 also draws attention to this problem, where 9

respondents out of 46 classified *Description of main tabs (Data, Display, Modules, Console, Python] and Map Display* as the advice that would help them most in their initial orientation in the software.

Question 4: What software do you think does a good job of providing a good first-time user experience? (optional)

In this optional question, QGIS is mentioned most often. However, the solution in GRASS may not be the same as in QGIS. Ideally it will be the best solution for GRASS, see #42 in Q3.

Selected Respondents	Response Date	Responses	Type
1	Oct 27 2020 02:56 PM	QGIS because it takes users to their data immediately rather than setting projects and folders. Creating location etc. is too old.	QGIS
4	Oct 26 2020 03:40 PM	QGIS	
14	Oct 24 2020 12:27 PM	I would consider the particular way QGIS writes help pages to be exemplary. The large pool of help videos by experts and users does the rest.	
15	Oct 24 2020 10:03 AM	Probably QGIS.....	
36	Oct 23 2020 02:12 PM	I really like (old) QGIS simple UI	
40	Oct 23 2020 12:53 PM	For someone completely new to GIS, none I would say. For users who some experience/knowledge in GIS I would say QGIS	
44	Oct 23 2020 12:13 PM	QGIS, it feels more intuitive, at least for the first experience of displaying a map. I really like to have everything in a single window, too. It's less confusing.	
13	Oct 24 2020 12:09 PM	Slack	Slack
16	Oct 24 2020 09:01 AM	slack	
32	Oct 23 2020 03:40 PM	Discord	Discord
28	Oct 23 2020 03:44 PM	Adobe photoshop	Adobe Photoshop
34	Oct 23 2020 03:41 PM	adobe photoshop	
38	Oct 23 2020 01:30 PM	Solidworks Ansys	Solidworks Ansys
29	Oct 23 2020 03:42 PM	google docs	google docs
10	Oct 24 2020 05:40 PM	Interactive tutorial = wizard	Other

Figure 59: Survey 1 Part 2 Question 4: Classification of open-ended responses (Source: Personal collection)

Question 5: Let's imagine you are a first-time user. What would help you significantly in your initial orientation in the software? Please, rank those features according to the importance (1 = the most important).

This question, where users sorted different features according to how much they would help them in their initial orientation, has no clear answers at all. Although the *Description of main tabs (Data, Display, Modules, Console, Python, and Map Display* variant has the lowest preference according to the median (see Figure 60) it appears very often on the first place as captured by the bar chart in Figure 61. The answers suggest that the software should provide advice on all of these selected aspects because more or less, all of these aspects are problematic for new users. The question remains what advice and in what form to include directly in the demolocation and what advice should no longer be included, but it should be well-referred to.

Description_of_main_tabs	Description_of_what_database_location_mapset_means	Brief_advice_on_how_to_start
Min. :1.000	Min. :1.000	Min. :1.000
1st Qu.:2.000	1st Qu.:1.000	1st Qu.:1.000
Median :3.000	Median :2.000	Median :2.000
Mean :2.391	Mean :1.761	Mean :1.848
3rd Qu.:3.000	3rd Qu.:2.000	3rd Qu.:2.000
Max. :3.000	Max. :3.000	Max. :3.000

Figure 60: Survey1 Part 2 Question 5: Descriptive statistics (Source: Personal collection - R analysis)

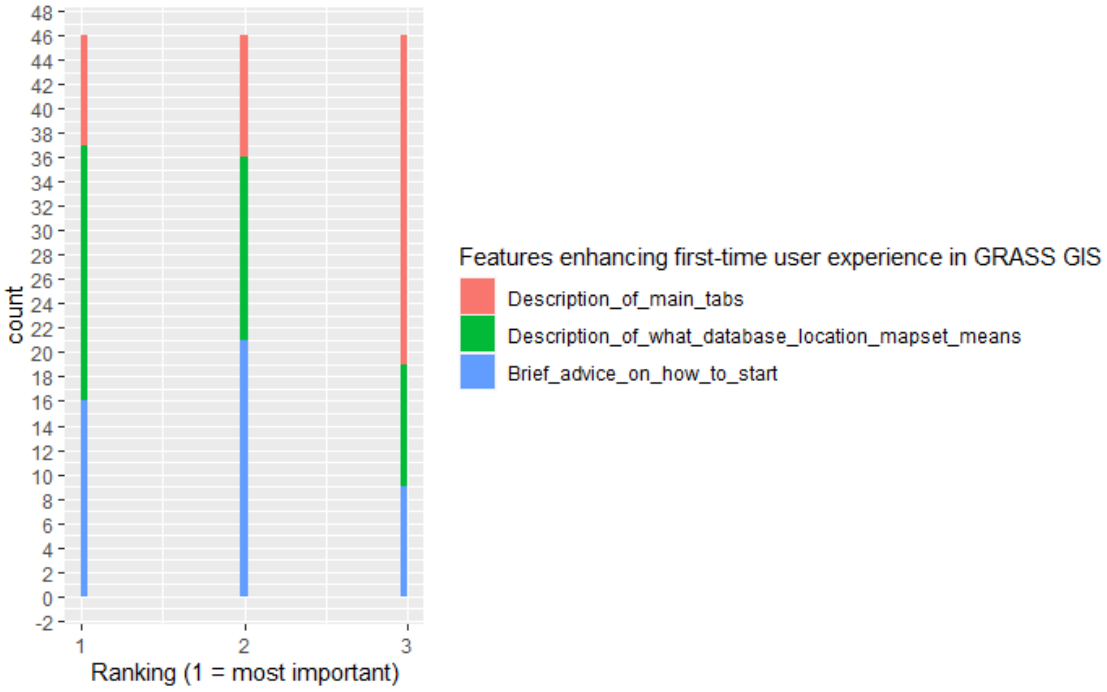


Figure 61: Survey1 Part 2 Question 5: Stacked Bar Chart (Source: Personal collection - R analysis)

6 GRASS GIS Development Proposals

As described in subchapter 1.5, this work consists of 2 seemingly independent parts. The first part (the main part of this work) related to Survey 1 Part 2 and Survey 2 improves the concept of default location by the so-called first-time user mode, which aims to improve the first-time user experience. The second part, related to Survey 1 Part 1, builds significantly on the changes made in the GSoC and addresses the shortcomings of the new startup mechanism. The first main topic of this work focuses exclusively on new users, while the second topic related to the complete removal of the original startup screen (so that it does not appear even in a situation where the last mapset is not in a usable state) is a topic that affects all users.

6.1 How to enhance the first-time user experience

After running GRASS in the version after GSoC for the first time, the user is redirected to the Data tab containing the default location (project template). The analysis of the second survey confirmed the assumption that in order to make GRASS a more user-friendly tool right from the outset, there is some form of help (whether in form of First Run Wizard or infobar) a necessity. Although the Data Catalog provides a visual idea of the hierarchical data structure in GRASS, no clue would explain the concept of the default location, nor locations and mapsets in general. But it's not just a misunderstanding of the GRASS data hierarchy, as the developers initially thought. Users also have problems with the meaning of tabs, especially with the Modules tab. The responses to Question 5 also point out that the advice on the data import would be useful as well.

In the most likely scenario, as a new GRASS user, we would try to import our data, display it in the required design, and perform analyzes. To do this, in the first step, we should create a location in the coordinate system of our data. In the second step, depending on the data type, we can already import vector or raster data. In the third step, we can visit the Modules tab if want to analyze the data straight away. However, if we only want to change the layer properties, we should go to the Display tab.

For these situations, the author has proposed the sequence of small hints which can be seen in Figure 62. Those texts displayed in the orange box essentially suggest a special first-time user mode, which we can also perceive as a First Run Wizard in terms of continuity. If the user follows the advice, he will eventually meet all three advice in that order. So it is not possible to skip this mode as in Zoner Photo Studio, but if we do not follow the advice, we can avoid it. Since small hints are displayed in predefined situations, it was decided to implement them with

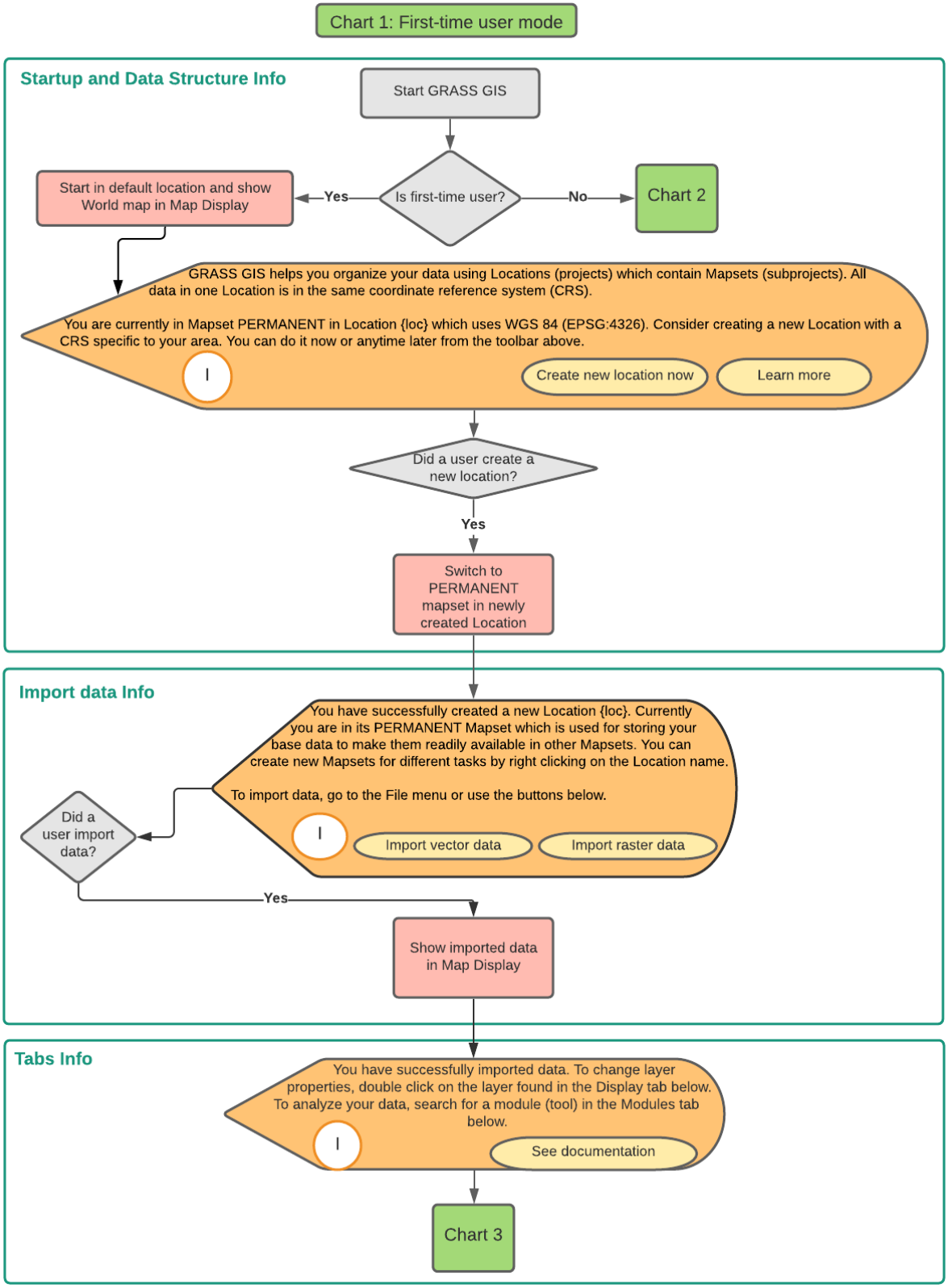


Figure 62: Flowchart of the first-time user mode (Source: Personal collection)

a similar solution that is used in QGIS 3 - in the form of an infobar. Except for hints, the infobar in GRASS will include a button(s) that offer the user the necessary functions without the need to search. A more detailed description of the first-time mode, including infobar mockups, is contained in section 7.

6.2 How to improve GRASS GIS startup mechanism

In Survey 1 Part 1, Q4 and Q5 mainly concern the Data Catalog and Management Icons, which development is important, however, the implementation is beyond the scope of this work. From the point of view of this work, the most important question is number 2, which solves the case when GRASS wants to start in the last used mapset, however, this mapset is not available for one of these reasons - it has either been deleted or it is used by another process. Unfortunately, this question was not drafted very cleverly in terms of the answer options offered, which is evident from a large number of open-ended responses.

At first glance, the number of respondents who would choose the modernized version of the startup screen prevails. However, only 2 out of 10 open-ended responses suggest some form of the startup screen. Although the total number of respondents proposing a startup screen is 34 (32 + 2), ie. 65 % percent of all respondents, we can not talk about a significant majority opinion. Besides, in open-ended responses, ideas with some form of information or error message very often appear, which is a very interesting variant, which the author of the work did not think of when compiling the survey. In terms of implementation complexity, however, it is a simple option, as the proposed infobar for first-time users can cover both purposes - it will primarily serve as a help for new users and secondarily it can serve as an information channel for existing users. In the latter context, the infobar can inform users about non-standard situations and speed up their work (e.g. when creating a location, it will automatically offer the creation of a mapset, etc.).

The display of the infobar in a non-standard situation is related to the existing startup mechanism, which still has not completely gotten rid of the old startup screen. If we start GRASS GIS for the first time, we meet a default location. In other cases, GRASS tries to boot into the last used mapset. However, there may be a problem where the last used mapset is not in a usable state. Two suggestions on how to solve this situation were compiled, which are presented using Flowcharts in Figures 63 and 64, where the second proposal is an extension of the first proposal.

In the first proposal in Figure 63 we do not consider the last used location at all. If the last used mapset is in a unusable state, the user will always be redirected to the default location. We do not prohibit the user from working in the default location as in the normal location. Then, however, there is a risk that the PERMANENT mapset can be used by another process.

This situation can occur, for example, when a user starts two GRASS sessions. The first instance starts in the last used mapset, but the second instance can no longer start this way.

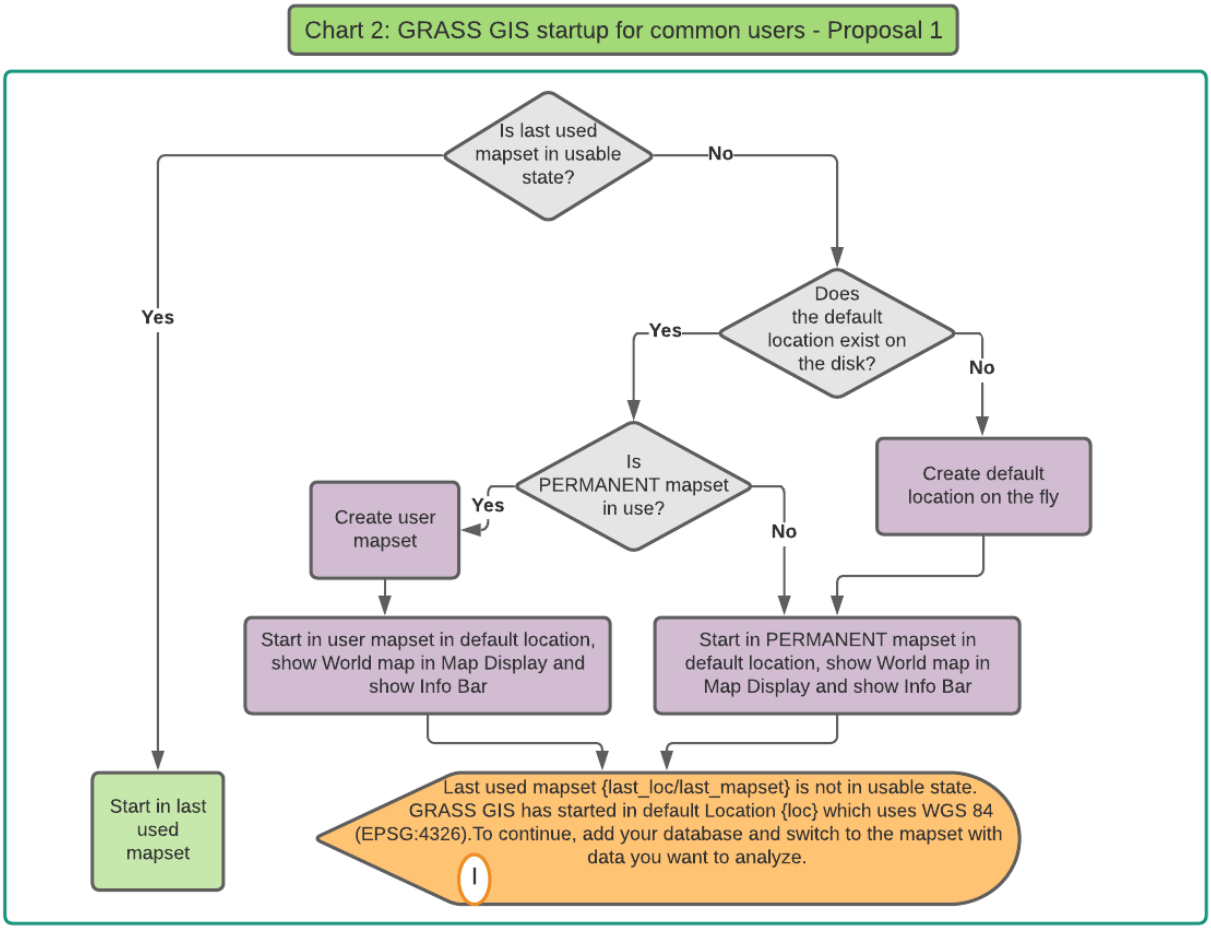


Figure 63: Flowchart of GRASS GIS startup for common users: Proposal 1 (Source: Personal collection)

It is therefore essential to check whether the PERMANENT mapset in the default location is in the usable state and if it is not, we need to create a new mapset in the default location, into which GRASS will start in case of an emergency. This mapset can be named after the user, which is a concept proposed in the second survey as a standard solution for first-time users. (In the end, it was not implemented since the second survey found that the existence of a user mapset in the standard version of the default location is rather confusing than useful).

When starting in the default location, the user will see the notification in the form of the infobar saying the reason of start in the default location and advising a user on what to do next in this situation. The solution is simple as in the new version of the Data Catalog after GSoC it is very easy to add a new database to the Data Catalog, create a new location, etc. The infobar can therefore have the character of an information icon, as in the case with help for first-time users.

Proposal 1 can be extended with another idea. To offer the user the most similar state to the last GRASS run, we can start GRASS in the PERMANENT mapset of the last used location. However, it presents a new concept, which assumes that the PERMANENT mapset is some kind of default mapset. This would mean incorporating this idea into other segments of GRASS. For example, in the Data Catalog context menu, there should be a possibility to switch to location (its PERMANENT) from the location node. In this proposal, the default location is taken as the last unwelcome option employed only when the last used location either does not exist at all or exists, but it is not possible to open the last used mapset or PERMANENT mapset.

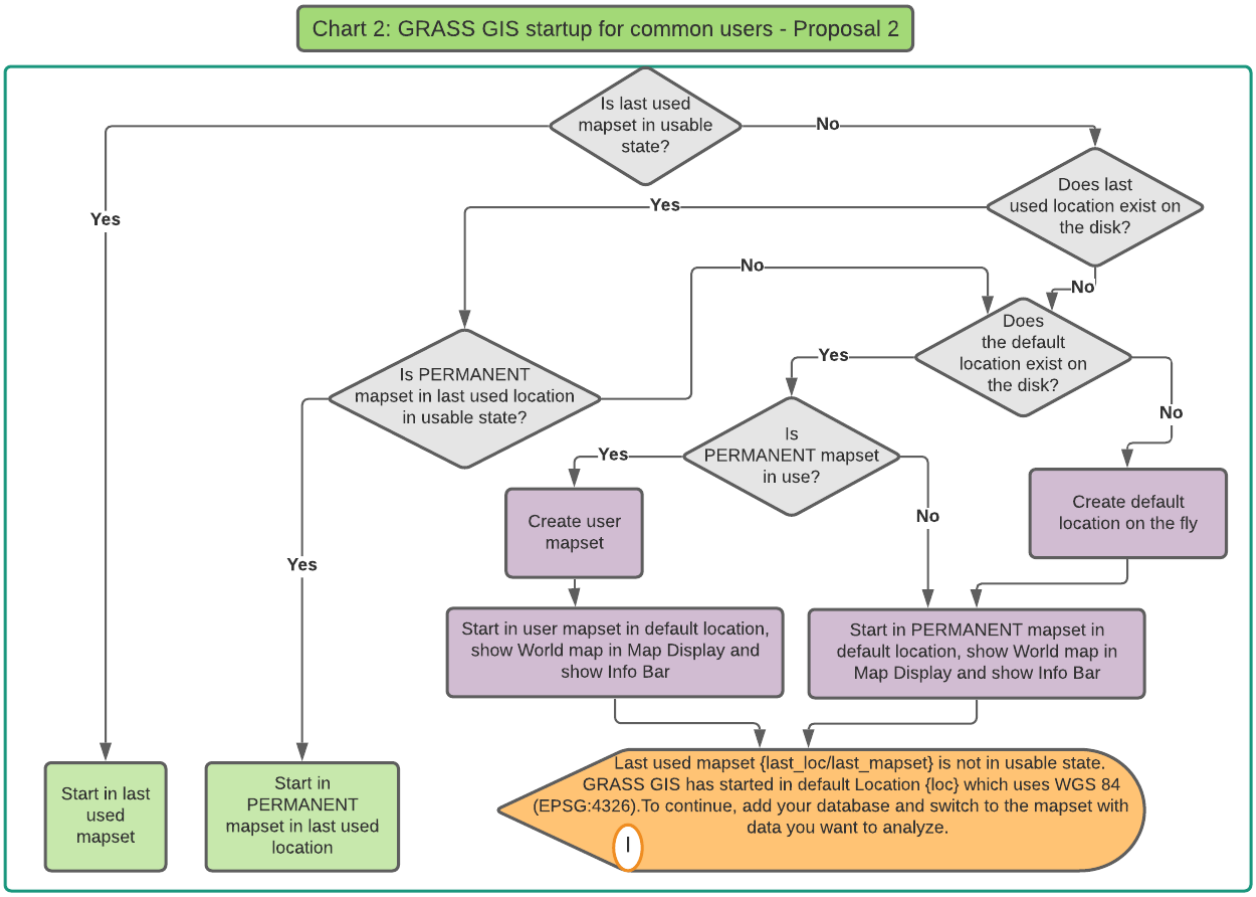


Figure 64: Flowchart of GRASS GIS startup for common users: Proposal 2 (Source: Personal collection)

However, the disadvantage of the second solution is that the GRASS GIS startup process would not be consistent. The first solution is always consistent - boot in the demolocation in each non-standard situation and provide the same message in the infobar. Since this massage is closely related to the Data Catalog and data hierarchy in GRASS GIS in general, we can use the same object of infobar which is used for messages intended for first-time users.

We could also think of other situations where the infobar could be displayed to users (see Figure 65). For example, when creating a new location, it can be assumed that the user will

subsequently request the creation of a mapset. Similarly, when creating a database, it can be assumed that the user will want to create a new location in the next step. The notifications could therefore be a kind of guide intended not only for first-time users. Their purpose would be to speed up the user's work related to the organization of their data. It could also be the same infobar object placed in the data tab, however, this time the type would not be informative, but questional.

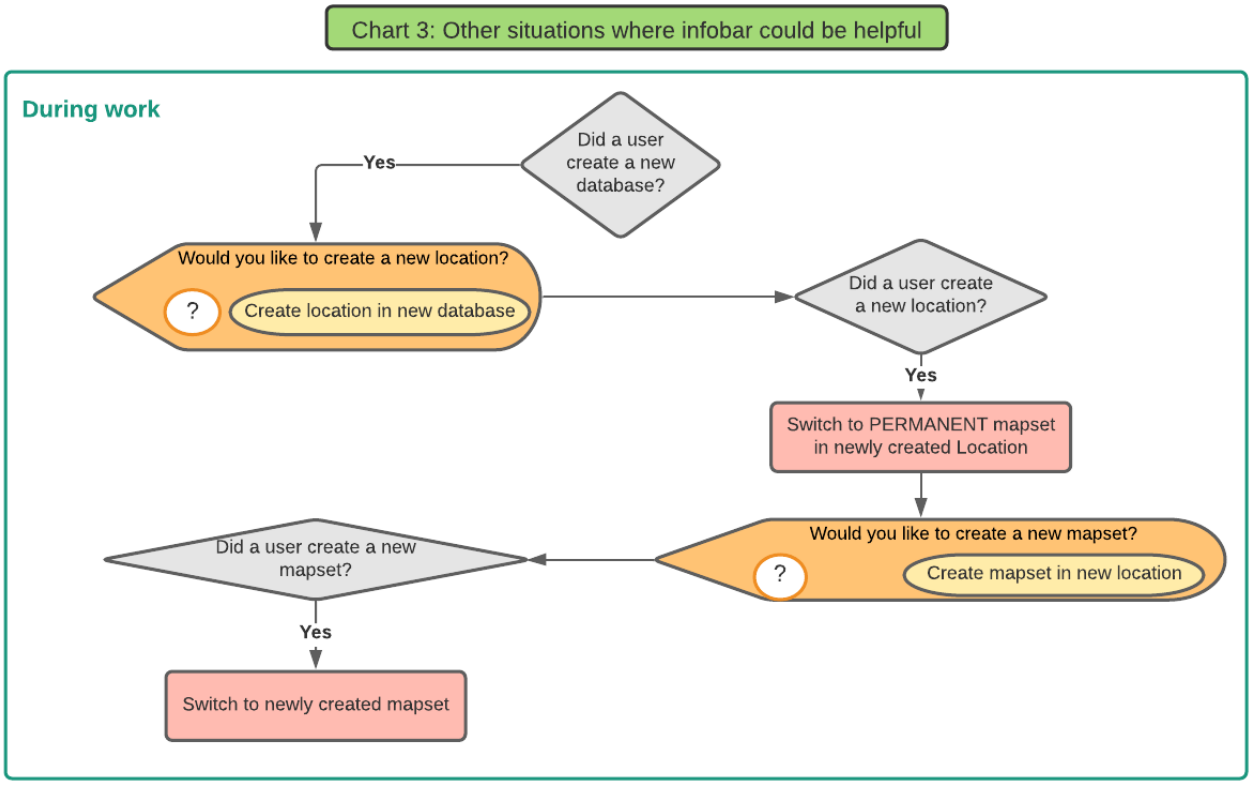


Figure 65: Flowchart of other situations where the infobar could be helpful (Source: Personal collection)

7 Analysis of the second questionnaire

The second questionnaire called **Help improve the special mode for first-time users** was released on November 26 and stopped on November 30, 2020. It introduces a new infobar solution to new and existing users and tests its success. At the same time, it addresses users to share their ideas on how to modify and adapt the solution so that the resulting solution that emerges from this work, largely based on this survey, enriches the first-time user experience with GRASS as much as possible.

The questionnaire is based on a simple task. A user has vector data of rivers in the Czech Republic in the shapefile format in the coordinate system S-JTSK/Krovak East North (EPSG:5514) and they would like to import this data into GRASS and perform a simple task – extract a river called Otava and save it in a separate layer. Unfortunately, due to external circumstances, this task could not be tested among GRASS beginners directly on the software. Thus, a survey was designed that simulates three key situations. These situations are according to the diagrams in the previous chapter and according to the results of Survey 1 Part 2 crucial. The questionnaire provides the user with three simulated situations in the form of infobar mockups and finds out if they let him to the right decision on how to continue in work. In the following text, the term *default location* is preferred to the term *demolocation*, which is more of a technical (developer) nature. Semantically, these concepts do not differ.

The first situation shown in the mockup in Figure 66 shows the GRASS GIS immediately after startup. At this point, a user needs to find their way around in a completely unknown environment as quickly as possible and import the data in order to perform analyses. GRASS GIS starts to the default location, which in the Map Display window displays the world map in the WGS 84 system (EPSG:4326). The task of the default location is to give the user a certain sense of security by showing a map and at the same time an example of data organization in the Data Catalog, which is now the center of GRASS. At the first moment, it is therefore essential for the user to at least passively understand the principle of the GRASS data hierarchy, which is well visible in the Data Catalog and also briefly explained in the first infobar. The data hierarchy terms are also specified in the text using new planned names in parentheses. In order to properly figure out the first situation, a user must realize that the data he wants to import into the software has a different coordinate system (EPSG:5514) than the one defined for the default location (EPSG:4326). This means that if a user understands the meaning of the location, he will create a new location that will have the coordinate system of the data he wants to import. The user can also click on a button “Learn More” linking the website [8] which contains a detailed explanation of the data hierarchy.

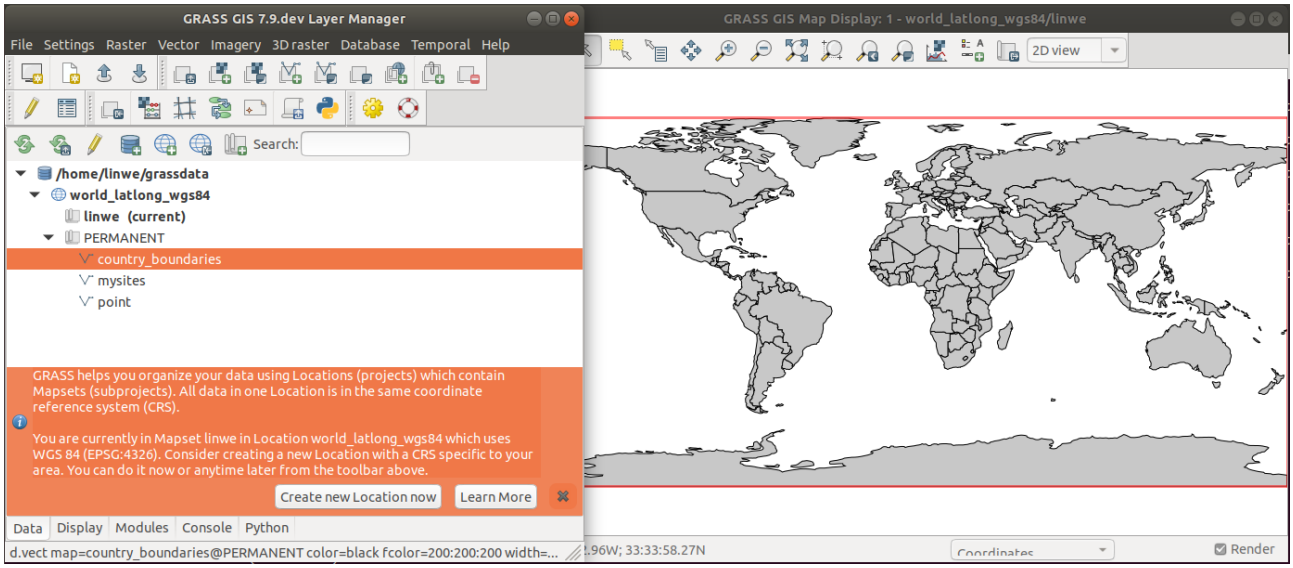


Figure 66: Survey 2: Situation 1 (Source: Personal collection)

Once a user creates a new location, he finds themselves in **the second situation** captured in Figure 67 which displays the second infobar leading to data import. This infobar also explains the concept of PERMANENT mapset and shows a variant of creating own mapset, which is not necessary but useful. It means that we are still partially dealing with the topic of data hierarchy in GRASS, but at the same time, we advise the user on how to import their data. After successful import, a map is displayed automatically in the Map Display.

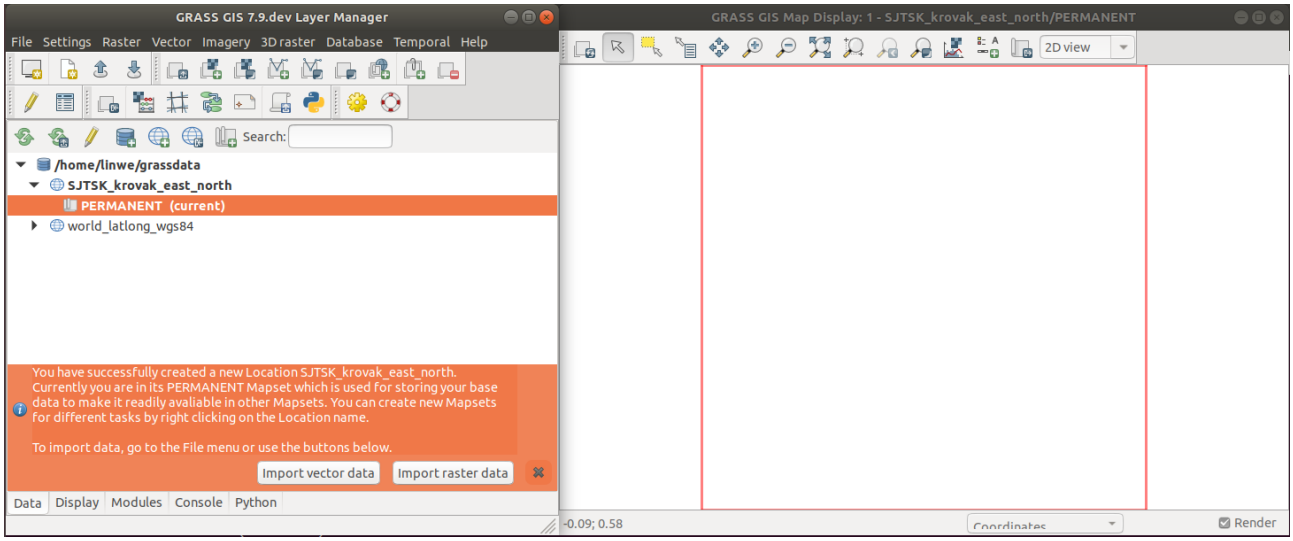


Figure 67: Survey 2: Situation 2 (Source: Personal collection)

The result of Question 5 in Survey 1 Part 2 shows that users also have a problem with the meaning of individual tabs. After importing the data, a user wants to either analyze data

directly or change its display in the Map Display (e.g. change transparency, strength, line color, etc.). Therefore, in **the third situation** shown in Figure 68 the author introduces the two main tabs called Modules and Display and link the documentation GRASS website [34] via "See documentation" button. As a reader probably noticed, the proposal is trying to provide basic advice on all of the aspects that appeared in Survey 1 Part 2 Question 5.

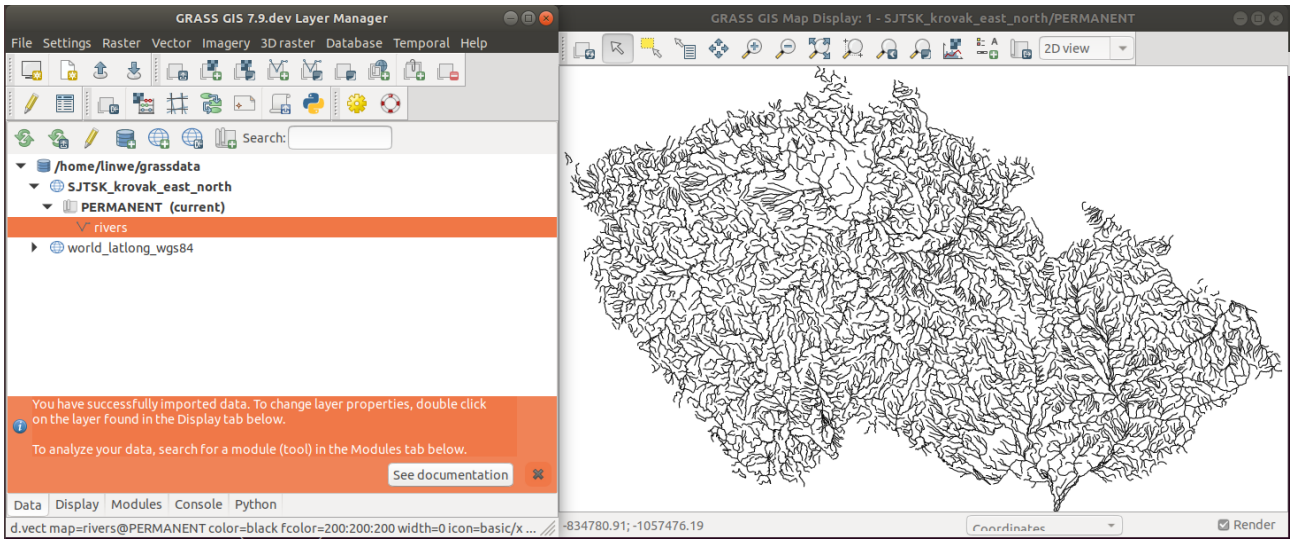


Figure 68: Survey 2: Situation 3 (Source: Personal collection)

The survey was visited by 32 respondents, 25 of them provided relevant responses. The completion rate among relevant respondents was 96 %. We can see a weekly graph of the number of responses for a specific day in Figure 53.

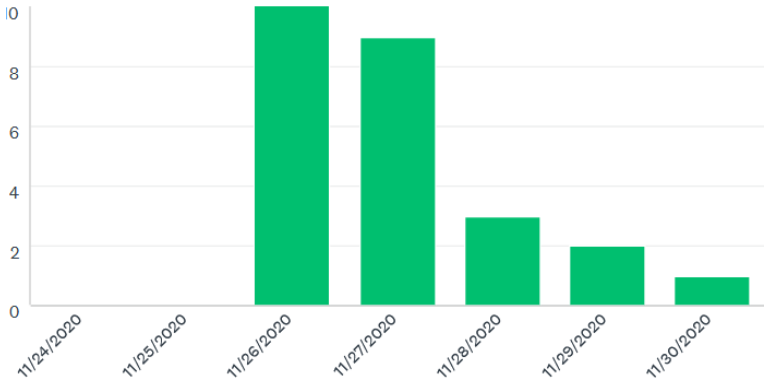


Figure 69: Survey 2: Responses by day (Source: Basic analyzes provided by the SM)

The questionnaire consists of 10 questions - 6 questions concern the understanding of individual situations, 2 questions are complementary and 2 more questions find out how experienced the interviewer is - both in terms of GIS in general and in terms of GRASS GIS.

The responses were divided into two groups with regard to the GRASS experience of individual respondents. The first group called **Occasional GRASS users** includes respondents who use GRASS less than sometimes (they chose less than 50 points in Q10) while the second group called **Frequent GRASS users** includes users who use GRASS more often than sometimes (they selected more than 50 points or 50 points in Q10).

According to Q9, the **Occasional GRASS users** group (see Figure 70) consists mainly of beginners and a minority of advanced or intermediate GIS experts (a total of 10 respondents) while the **Frequent GRASS users** group (see Figure 71) includes mainly GIS professionals and some intermediate (a total of 15 respondents).

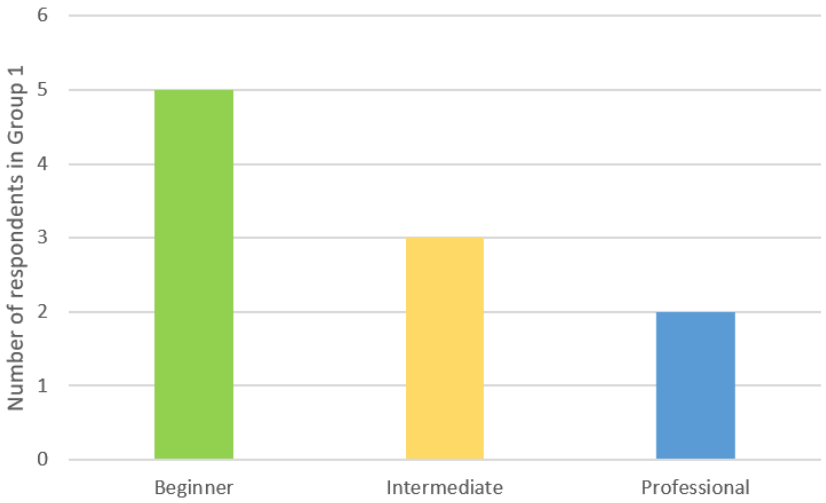


Figure 70: Survey 2: GIS proficiency of **Occasional GRASS users** group (Source: Personal collection)

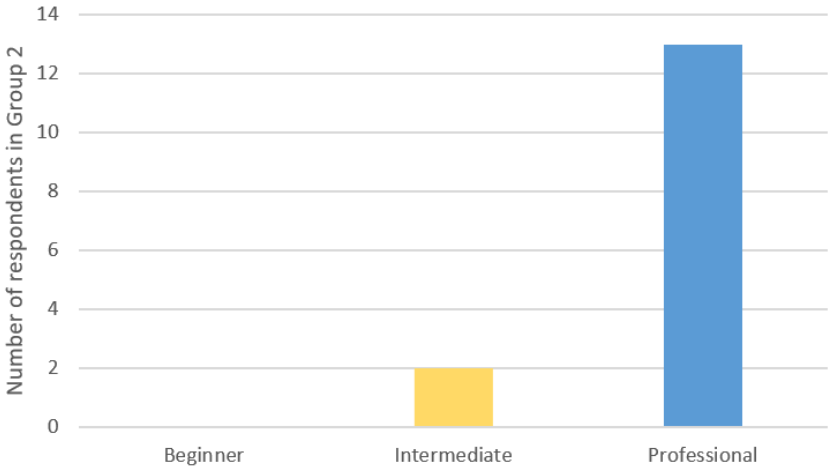


Figure 71: Survey 2: GIS proficiency of **Frequent GRASS users** group (Source: Personal collection)

Questions Q2, Q4, Q6, and Q8 has a type of Comment Box, which means that respondents shared their feelings and ideas in the form of open-ended responses. These are divided into six categories throughout Survey 2:

1. Demolocation/infobar confused
2. infobar could be ignored
3. Terminology should be changed
4. infobar too long / Editing of content in infobar
5. infobar Helped
6. Other

The answers in Figures 74, 77, 80 and 85 are sorted from the most serious category to the least serious. Only the last sixth category varying in importance and consists of responses that do not fall into any of the previous categories. The following lines analyze in detail the answers from Q1 - Q8 with regard to the user experience that arises from Q9 and Q10.

Question 1: What will be your next step in first situation?

There was only one correct choice for this Multiple Choice answer, namely "I will create a new Location ". The first situation was solved correctly by 17 out of 25 respondents (see Figures 72, 73). In the **Occasional GRASS users** group, 5 respondents solved it correctly, i.e., half of them. Even though the sample of users is very small, half of the people is definitely a success, because, without help, a very new or little experienced user probably wouldn't have thought to create a new location at all.

Question 2: Is something confusing to you? If so, what specifically? ? (Optional)

This open-ended optional question was answered by 9 respondents and comments can be seen in Figure 74. As respondent #21 points out, it is somewhat confusing that the default location contains two mapsets - not only the PERMANENT mapset, which must be included in each location, but also the user-named mapset. The world map is intentionally placed in the PERMANENT mapset because this mapset is intended for storing and displaying basic data. However, analyzes should always be performed in a mapset other than PERMANENT. Therefore, at the end of GSoC, it was decided that the default location will also contain a user-named mapset set as **current**. This solution was supposed to motivate users not to use

PERMANENT mapset for their further analyzes, but to sort their data into other mapsets. However, it is confusing since we display layers from non-current mapset. Therefore, it would be probably clearer for first-time users if the default location contained only the PERMANENT mapset with the included world map. After all, advice on the use of other mapsets is already part of the infobar in the second situation. Alternatively, a brief explanation of the term mapset could still be part of the first infobar, as suggested by respondent #24.

Response #11 indicates that a user may not realize that he or she is in a default location at all. This would need to be emphasized more. Respondents #13 and #17 fear that users will ignore the Info Bar. So another important step would be to think about how to highlight the infobar as much as possible so that most new users will really read it. However, as we can see from the responses #10 and #24 as well as from the number of correct answers in Q1, the info bar, even in the form in which it appears in this initial proposal, is certainly an improvement for new GRASS GIS users.

Figure 72: **Occasional GRASS users**: Bar Chart for Question 1 from Survey 2 (Source: Personal collection)

Question 3: What will be your next step in second situation?

There were two correct choices - either import the data using the *Import vector data* button or go directly to the File menu, where a user would find the corresponding function called *Simplified vector import with reprojection (v.import)*.

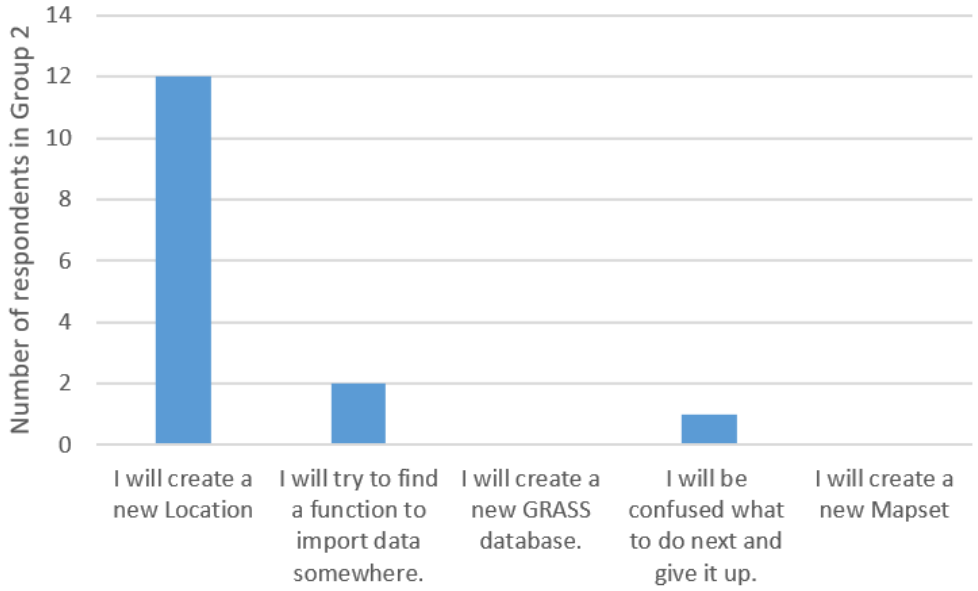


Figure 73: **Frequent GRASS users**: Bar Chart for Question 1 from Survey 2 (Source: Personal collection)

As we can notice in Figures 75, 76, both groups have been successful, 18 people out of 25 would choose to import data via the button in the infobar, only 5 people would search in the File menu.

Question 4: Is something confusing to you? If so, what specifically?? (Optional)

As the comment #14 in Figure 77 points out, it is not clear from the infobar that it is the import using the *v.import* or *r.import* modules. It is important to make sure that the user who clicks on the button in the infobar will be able to run this function afterward without having to search for it. Therefore, the buttons could contain bitmap images in addition to the text. Creating a location already has its image used for management icons, for data import it would be useful to add basic functions for data import also to the management icons. However, the question is whether to implement the buttons in the infobar at all. Perhaps it would be clearer to lead a user directly to the File menu or to the upper toolbar containing management icons, as respondent #10 suggests.

The comment number #13 encounters the problem that the first help in the infobar is not clearly related to the Data Catalog. Therefore, the infobar in the first situation could also contain small icons next to the explanation of location and mapset, which are used to distinguish the data hierarchy elements in the Data Catalog. Another part of the users encounters problematic terminology in GRASS. In this case, according to the author's opinion, it is worth waiting for how helpful will the infobar be for first-time users.

Respondents	Response Date	Q2: Is something confusing to you? If so, what specifically?	Response topic	Q9:What is your general experience with GIS?	Q10: How often do you use GRASS GIS? (0= never used GRASS, 100=every day)
11	Nov 27 2020 01:05 PM	Why are there already layers in the project?	Demolocation confused	Beginner	3
21	Nov 26 2020 8:58 PM	The note says we are in linwe mapset but we are seeing a map that is in PERMANENT. Will this map display by default when a user first open grass? If yes, message should change.	Demolocation confused	Professional	80
14	Nov 27 2020 12:25 AM	In the pop-up bar I miss a reason why I should create a new location.	Info Bar confused	Professional	100
13	Nov 27 2020 12:48 AM	Not sure I need a world map to start with, even though I don't dislike the idea. I am a ~experienced Grass user, so I'd create a location with the proper projection that differs from WGS84 if needed (and maybe a less wide region than the whole world?), but I am not sure that a first time user would give much weight to the warning.	Info Bars could be ignored.	Professional	100
17	Nov 27 2020 6:40 AM	While not having a great suggestion I am afraid that many people don't read the info box but just search around for the usual "open file" button(s).	Info Bars could be ignored.	Professional	100
21	Nov 26 2020 8:58 PM	And maybe it should also say something about create a new location with the CRS of user's data and importing with reprojection	Editing of content in Info Bar	Professional	80
24	Nov 26 2020 4:46 PM	I think you could add a short sentence about mapsets at the end of the first paragraph.	Editing of content in Info Bar	Professional	54
10	Nov 27 2020 3:04 PM	If the help didn't shine on me, I would probably try to import the data.	Info Bar helped	Beginner	0
24	Nov 26 2020 4:46 PM	The message in the orange box is already a great improvement for helping beginners.	Info Bar helped	Professional	54

Figure 74: Survey 2 Question 2: Classification of open-ended responses (Source: Personal collection)

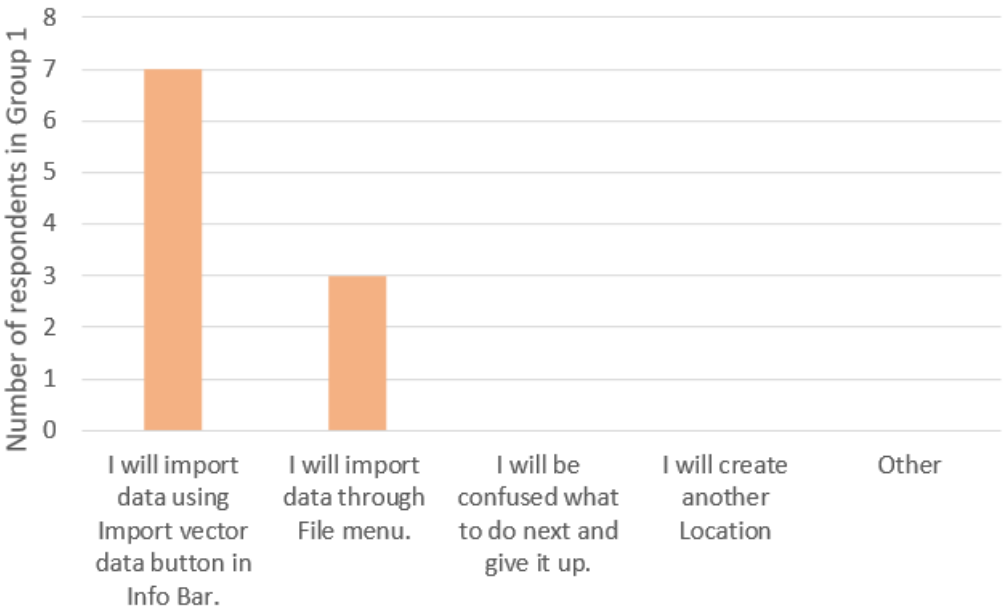


Figure 75: **Occasional GRASS users**: Bar Chart for Question 3 from Survey 2 (Source: Personal collection)

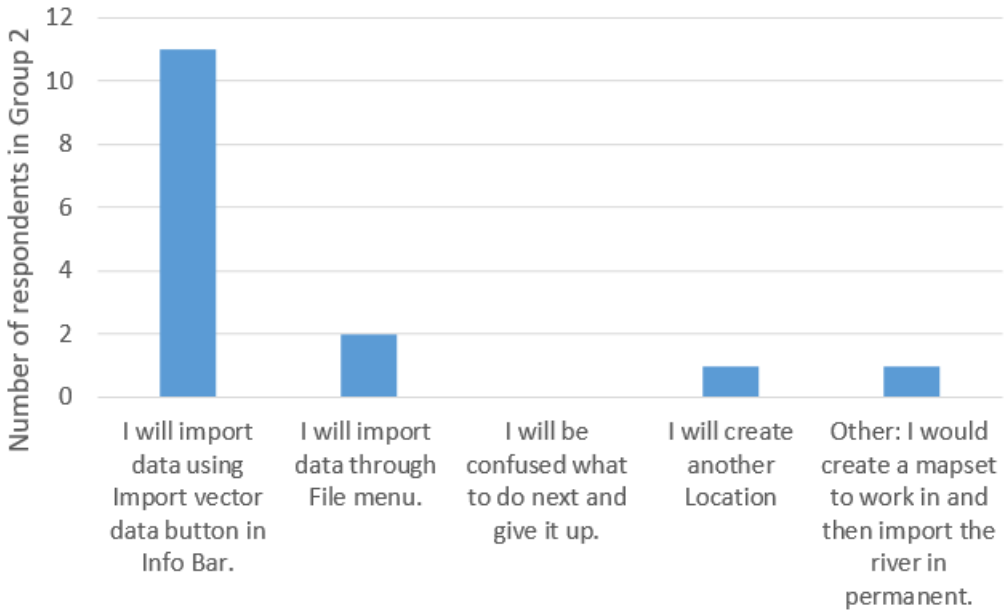


Figure 76: **Frequent GRASS users**: Bar Chart for Question 3 from Survey 2 (Source: Personal collection)

Only after a certain time when this mechanism will be functional can we conclude whether it will be necessary to change the terminology of the data hierarchy or whether the new startup mechanism is so straightforward to new users that most of them will get their way around without problems.

Respondents	Response Date	Q4: Is something confusing to you? If so, what specifically?	Response topic	Q9:What is your general experience with GIS?	Q10: How often do you use GRASS GIS? (0= never used GRASS, 100=every day)
14	Nov 27 2020 12:25 AM	Which button is the "import vector data button"?	Info Bar confused	Professional	100
24	Nov 26 2020 4:46 PM	I think the names are confusing. What do you think about renaming: "Location" as"AOI", "Mapsets" as "Datasets", "Permanent" as "Base data".	Terminology should be changed	Professional	54
17	Nov 27 2020 6:40 AM	Probably the term "location" should be abandoned in favour of "project".	Terminology should be changed	Professional	100
21	Nov 26 2020 8:58 PM	Instead of base data, I'd use "base maps" and examples between parenthesis	Terminology should be changed / Editing of content in Info Bar	Professional	80
13	Nov 27 2020 12:48 AM	Not clear that the one above is the list of locations in a tree. Took me some seconds to get it. Cool! Nice one, leave this configuration please (but maybe write somewhere 'locations'?).	Editing of content in Info Bar / Info Bar confused	Professional	100
10	Nov 27 2020 3:04 PM	Maybe in the help to guide the user directly to the file menu than to provide him a shortcut via a button.	Editing of content in Info Bar	Beginner	0

Figure 77: Survey 2 Question 4: Classification of open-ended responses (Source: Personal collection)

Question 5: What will be your next step in third situation?

Two users who selected the Other option, would double-click on a vector layer to obtain layer properties. It can be concluded that these users did not understand the function of the Data Catalog. In the Data Catalog, it is only possible to display the metadata of the layer, if we want to change the display properties of this layer, we have to go to the Display tab. It is also interesting that from **Occasional GRASS users** only 1 person would go straight to the Modules tab, while for Frequent GRASS users this option prevails. As we can notice in Figures 78 and 79, the half of **Occasional GRASS users** would then look to the documentation, from **Frequent GRASS users** only three people would do so.

Question 6: Is something confusing to you? If so, what specifically?? (Optional)

The first survey shows that people have problems with the meaning of tabs. Like respondent #15, also other users may be confused by the purpose of the Data and Display tabs.

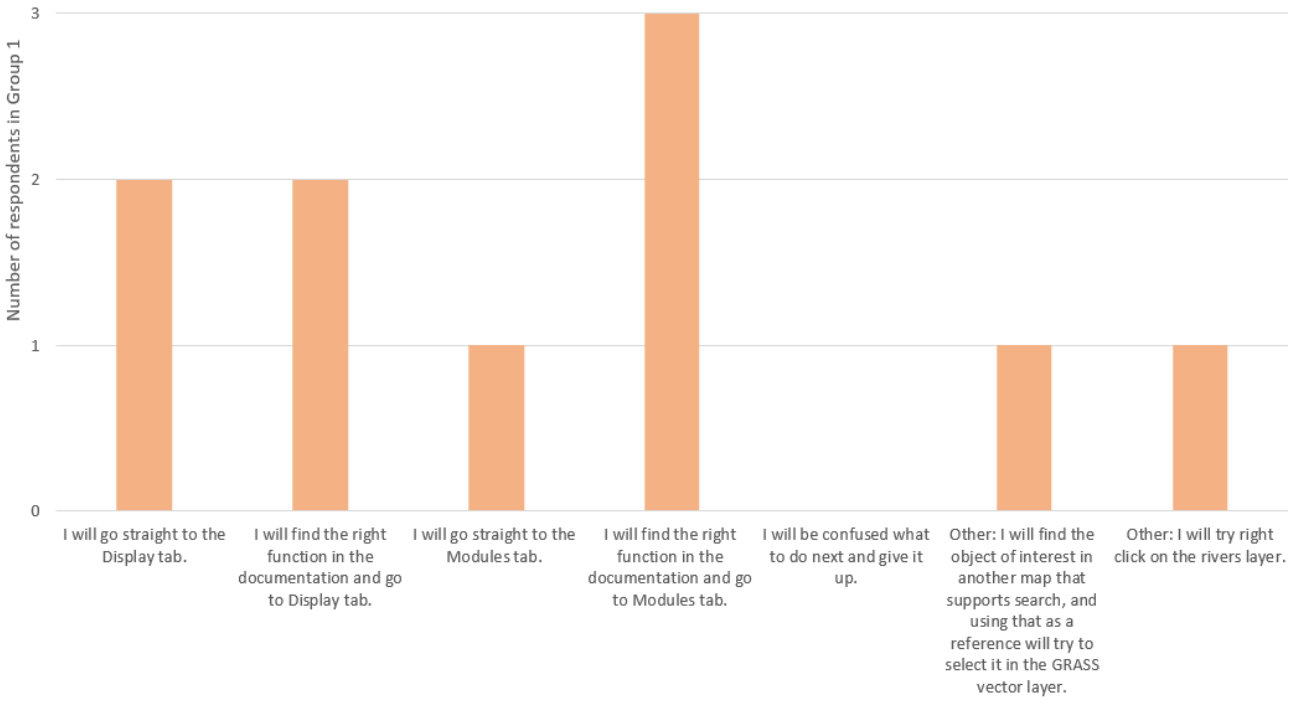


Figure 78: **Occasional GRASS users**: Bar Chart for Question 5 from Survey 2 (Source: Personal collection)

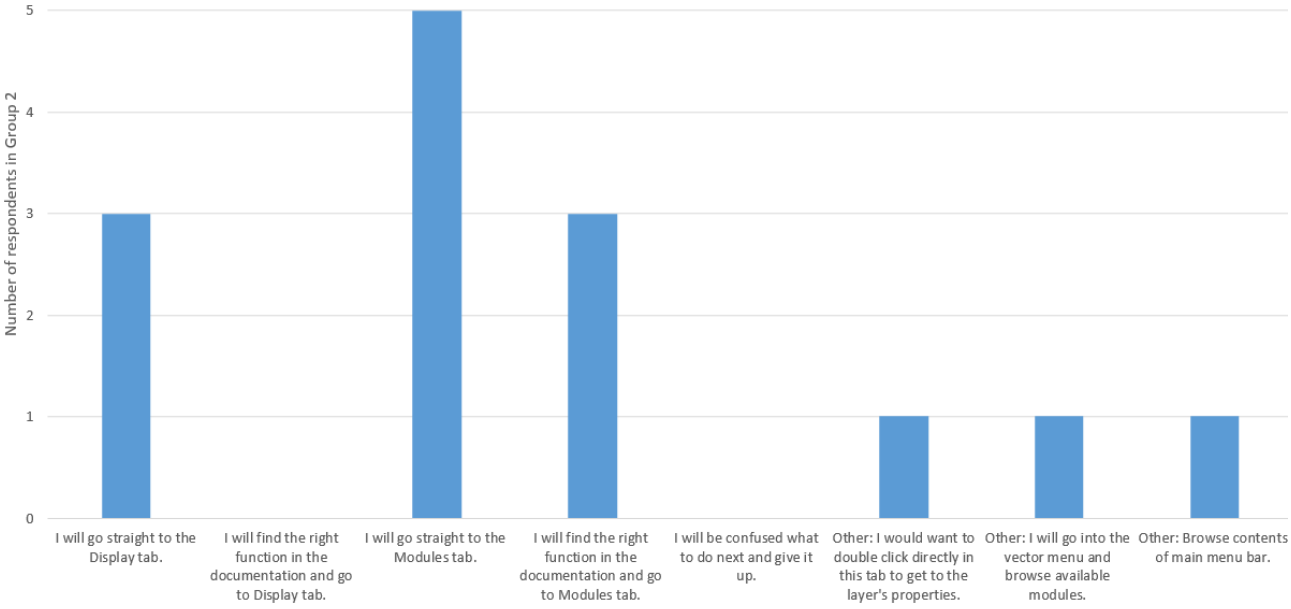


Figure 79: **Frequent GRASS users**: Bar Chart for Question 5 from Survey 2 (Source: Personal collection)

Respondents	Response Date	Q4: Is something confusing to you? If so, what specifically?	Response topic	Q9:What is your general experience with GIS?	Q10: How often do you use GRASS GIS? (0= never used GRASS, 100=every day)
15	Nov 27 2020 11:25 AM	Where are map layers and their properties located? Why I am looking at file list if I want to manage map layers?	Info Bar confused	Professional	80
24	Nov 26 2020 4:46 PM	To me again, it is the wording that is confusing. Why are "tools" called "modules" and not simply "tools"?	Terminology should be changed	Professional	54
21	Nov 26 2020 8:58 PM	I'd write: "To change layer properties, go to Display tab below and double click over layer name". I think the message is clearer in this way.	Editing of content in Info Bar	Professional	80
10	Nov 27 2020 3:04 PM	I view the documentation only when I can't find the function in another way.	Other	Beginner	0

Figure 80: Survey 2 Question 6: Classification of open-ended responses (Source: Personal collection)

The Display tab was only renamed from original *Layers* tab within GSoC and moved to the second place in the order of tabs. The Data tab (previously in the fourth place in the tab order) was placed in the first place. The Data tab has the character of a data directory and is only used to organize data in GRASS GIS. A very distant counterpart called Catalog can be found in ArcGIS. Map layers and their properties are located in the Display tab. In the infobar in the third situation, it would be helpful to better explain the difference between the Data and Display tabs. Similarly, it could help to change the terminology of Modules to *Tools*, as suggested by respondent #24 in Figure 80.

Question 7: What do you think about the following statement? The advice in infobars given in each situation was straightforward and led me very well to the right answers.

The agreement with this statement is significantly higher for the group **Frequent GRASS users** as seen in Figures 83 and 84. It was expected since the perception of these users is somewhat distorted by the knowledge of GRASS. For the **Occasional GRASS users**, however, the average of 53.5 is also not disappointing. Despite the very small number of respondents, we can conclude that there are more **Occasional GRASS users** who like the infobar solution than dislike it.

It is important to admit that the survey indicates what the respondent should pay attention to. This is not only since a user has a choice of multiple answers but also to the topic of the survey itself. It is therefore clear that in practice the success of the infobar can be different.

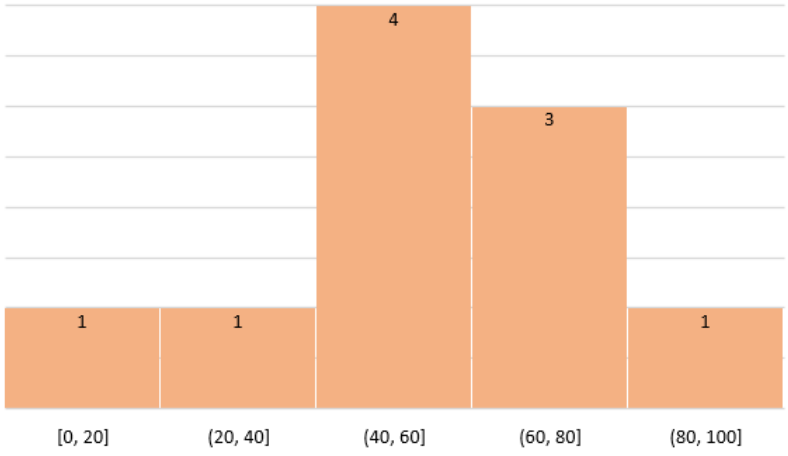


Figure 81: **Occasional GRASS users**: Histogram for Question 7 from Survey 2 (Source: Personal collection)

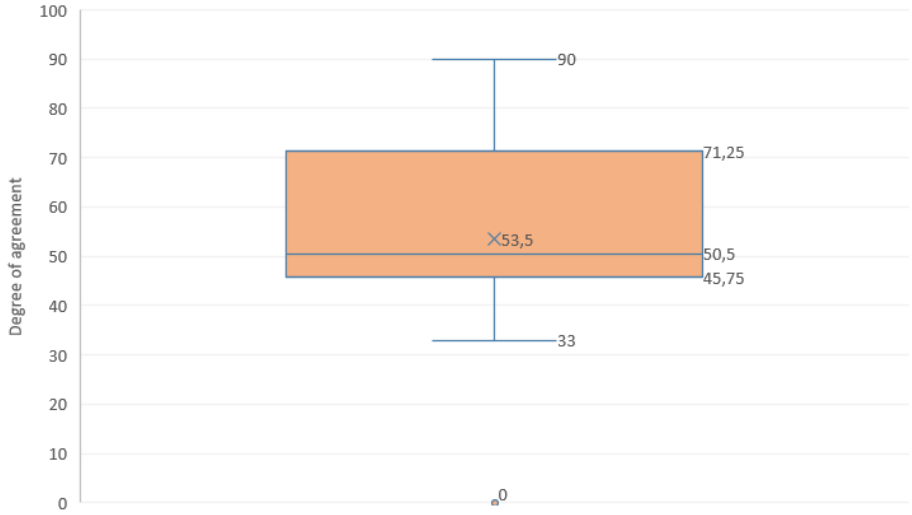


Figure 82: **Occasional GRASS users**: Boxplot for Question 7 from Survey 2 (Source: Personal collection)

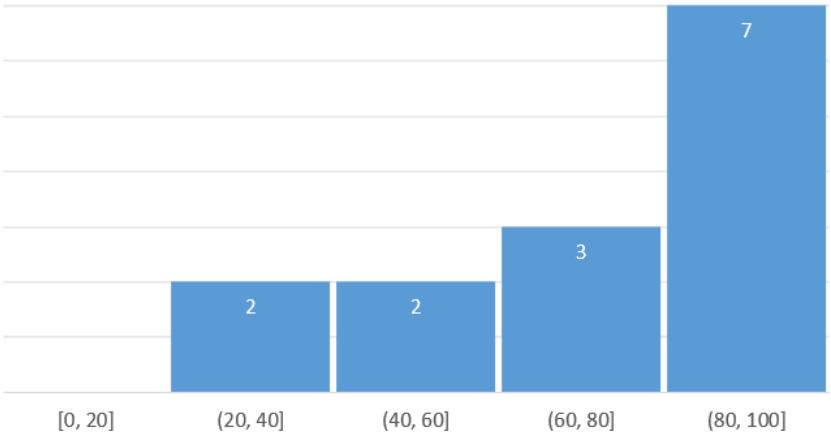


Figure 83: **Frequent GRASS users**: Histogram for Question 7 from Survey 2 (Source: Personal collection)

Question 8: Any ideas you want to share? (e.g. the change of wording in infobars, adding more information, or, conversely, the removal of some information) (Optional)

In addition to the required changes in terminology and concerns that the infobar will be ignored by users, several respondents said that the texts in the infobar are too long. There is an effort to shorten them as much as possible, but at the same time, it must contain everything needed. The text of the infobar is definitely not final and will be changed based on proposals in Pull Requests and also based on longer-term feedback from GRASS users.

A very valuable comment was given by respondent #18, who suggests placing the infobar above the Data Catalog (not below as presented in the proposal). This respondent also perceives the infobar as a warning message rather than an information message. It can be evoked by an orange color that was chosen deliberately in order to highlight the infobar and at the same time to match the color of the selected item of data hierarchy emphasized by the white text on the orange field as well. The infobar type (for example, information, warnings, or a question) is distinguished by a small icon on the left side of the widget. The infobar designed for first-time users has the character of an information message.

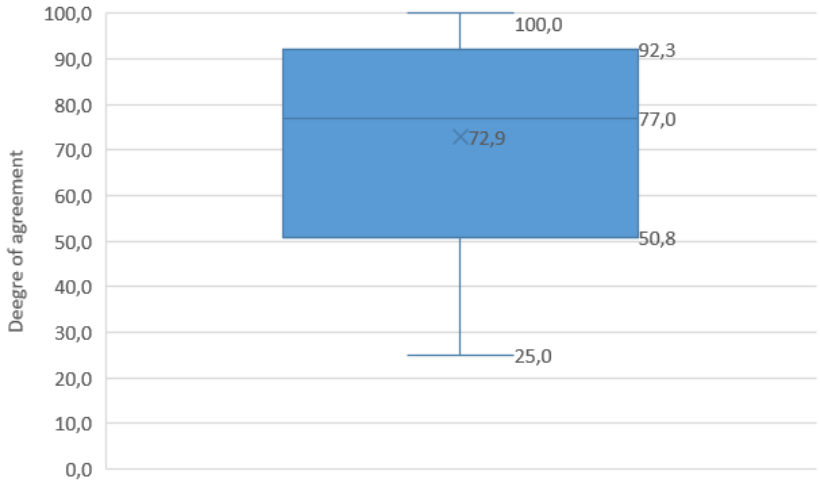


Figure 84: **Frequent GRASS users**: Boxplot for Question 7 from Survey 2 (Source: Personal collection)

In terms of concept, the infobar in Data Catalog can be implemented with texts appearing in situations that have been identified based on the first survey. The concept, therefore, will be preserved. However, the second survey revealed some shortcomings which resulted in several changes:

- Removal of a user-named mapset from the default location
- Placing the infobar above the Data Catalog
- Text editing in the infobar stemming from the second survey

Alternatively, after successful implementation of this foundation, further improvements can be made:

- Adding basic functions for data import between Management icons
- Adding bitmap images to the buttons so that users know 100% what function they are calling through the infobar

Respondents	Response Date	Q2: Is something confusing to you? If so, what specifically?	Response topic	Q9:What is your general experience with GIS?	Q10: How often do you use GRASS GIS? (0= never used GRASS, 100=every day)
9	Nov 27 2020 6:53 AM	I did not pay attention to the infobars, to be honest.	Info Bars ignored	Beginner	25
18	Nov 26 2020 4:46 PM	I didn't read Info Bars, it looks like warning instead of advice.	Info Bars ignored	Intermediate	5
17	Nov 27 2020 6:40 AM	The term "location" might be abandoned in favour of "project" or the like, to make it less strange right away. PS: cool to gather opinions with the surveys!! Much appreciated	Terminology should be changed	Professional	100
24	Nov 26 2020 4:46 PM	Info Bars are great, well done! The next step, rather than explaining words such as location, mapset, permanent, module, etc. in info bars, would be to directly rename them.	Terminology should be changed	Professional	54
8	Nov 27 2020 7:15 AM	Too much text in the info bar	Info Bars too long	Professional	99
18	Nov 26 2020 4:46 PM	Ideally shorten, it's long enough.	Info Bars too long	Intermediate	5
17	Nov 27 2020 6:40 AM	The initial info box contains IMHO too much text. People are lazy to read...	Info Bars too long	Professional	100
11	Nov 27 2020 01:05 PM	Maybe some additional pop ups to direct the user to the module tab	Editing of content in Info Bar	Beginner	3
2	Nov 29 2020 05:29 PM	Information is helpful	Info Bar helped	Professional	47
10	Nov 27 2020 3:04 PM	One way to improve the help / introduction could be a sample tutorial on how to solve this task with Otava. Eg: Click there and there, create a project, load data from a given place, there and there you will find a search function that you will use with this parameter. (Said very simply :-D.)	Other	Beginner	0
18	Nov 26 2020 4:46 PM	I would consider moving Info Bars above the boxes, otherwise I will not read it as a user.	Other	Intermediate	5
14	Nov 27 2020 12:25 AM	Maybe discuss content of the infobars in a separate PR?	Other	Professional	100

Figure 85: Survey 2 Question 8: Classification of open-ended responses (Source: Personal collection)

8 Implementation

This chapter presents the implementation of the first-time mode from the technical point of view. As mentioned in subsection 1.1 GUI implementations use the wxPython – cross-platform GUI toolkit[10]. Currently, supported platforms are MS Windows, macOS, Linux, or other Unix-like systems. The resulting design on each platform can be a bit different. We can import wx to a script file as a package that wraps the GUI components of the popular cross-platform C++ library wxWidgets[11].

GRASS has a long history of versioning and reporting tickets/issues. Since January 2020 it has been developing on GitHub. GitHub stores the history of work, ensures stylistic consistency using the flake8 command-line utility, and also allows the creation of Issues (such as errors and improvements). These issues are usually proposed for changes (Pull Requests), which users discuss. Therefore, GitHub partly works as a social network, which supports the creativity and enthusiasm of developers. In the following text presenting the changes from the developer's point of view, the term *demolocation* is preferred to the term *default location*.

8.1 Displaying a world map and deleting a user mapset

Displaying a world map as a part of the default location is solved in the script *gui/wxpython/lmgr/frame.py* directly in the constructor of the GMFrame class, which represents the Layer Manager (see chapter 1.2). The map is displayed whenever the user is in the default location, this is checked via the location name *world_latlong_wgs84*.

The demolocation is automatically part of the GRASS GIS distribution. After the first run, it was copied on-the-fly to an automatically created database called "grassdata" and a mapset named after the user was created. However, based on Survey 2, the author found out that the user mapset is confusing. Therefore, the demolocation now starts in the PERMANENT mapset, which becomes the current mapset at startup. The change mainly affects the file *gui/wxpython/startup/utils.py*.

Pull Requests:

Displaying a world map: `https://github.com/OSGeo/grass/pull/1070`

Deleting a user mapset: `https://github.com/OSGeo/grass/pull/1173`

[10] `https://wxpython.org/`
[11] `https://www.wxwidgets.org/`

8.2 Special mode for first-time users

The basis of the new special mode for first-time users is the `InfoBar` class for which a new file in the path *gui/wxpython/gui_core/infobar.py* has been created. The file was intentionally created in the *gui_core* directory, as the `InfoBar` class is a general template and is therefore usable for other future InfoBar instances located elsewhere than in the Data Catalog. This class inherits from the implementation in the Advanced Generic Widgets (AGW). This package provides many custom wxPython controls that are simply an addition to the wxPython widgets set. In terms of Layout and displaying and hiding messages (and buttons), the infobar has been significantly adapted to GRASS GIS.

Next, the `DataCatalogInfoManager` class was created in the new script in the path *gui/wxpython/datacatalog/infomanager.py*. This class contains methods that define the individual info messages that will be displayed. It takes care of both the text and the buttons as well as functions that are called when the buttons are pressed.

Both `InfoBar` and `DataCatalogInfoManager` instances are created in the `DataCatalog` class in the *gui/wxpython/datacatalog/catalog.py* file. This class is a template for an object that is the content of the Data tab. The `DataCatalog` class contains first the `DataCatalogTree` object, which is often inaccurately called the Data Catalog, secondly the toolbar object `DataCatalogToolbar` in which the Management icons are located, and thirdly the newly implemented `InfoBar` object. In Figure 86 we can see a UML diagram that shows the classes described above and the relationships between them.

If the user is in the demolocation after startup, the world map is displayed and at the same time the infobar is visible, which displays advice and buttons for the first situation. The setting of the Info Bar for the second and third situation is no longer so straightforward. It is necessary to use Signals from the pydispatch library[12].

In the second situation, a Signal is created in the `DataCatalogTree` class and emitted if the user is in a demolocation and a new location is successfully created. At the same time, when generally creating a new location, there is always a switch to the PERMANENT mapset of the newly created location, which thus becomes the current mapset. The `showImportDataInfo` method is connected to the signal in the parent `DataCatalog` object, which calls `InfoManager` with the settings which is set in case of successful creation of a new location. The infobar is displayed in the second situation after creating a new location using the Management icon as well as after creating a location using the button in the infobar set for the first situation.

[12] `https://pypi.org/project/PyDispatcher/`

Showing the infobar in the third situation is also handled via Signal from the pydispatch library. Signal is created in the `ImportDialog` class in the *gui/wxpython/modules/import_export* file, which is the parrent for both the `GdalImportDialog` class for importing raster data as well as the `OgrImportDialog` class for importing vector data.

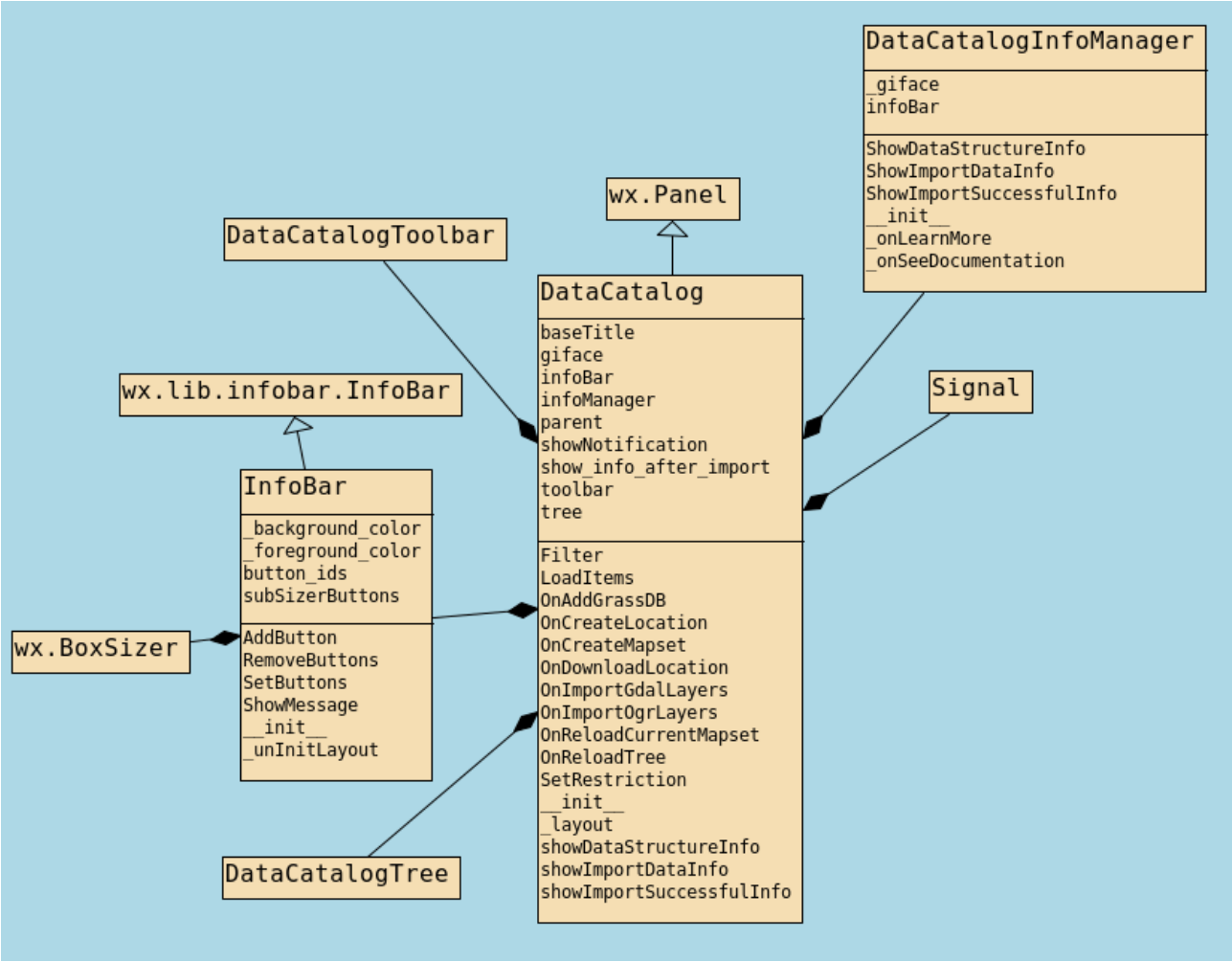


Figure 86: UML diagram of Infobar implementation (Source: Personal collection)

If the import is successful, this Signal is emitted. In the `DataCatalog` class, the `showImportSuccessfulInfo` method calling the `InfoManager` with the particular settings, is connected to this Signal. The infobar is displayed in the third situation after data import using the appropriate Management icons as well as after data import using the buttons in the infobar set for the second situation.

The infobar does not appear if the user creates a location or imports data from the File tab. In this case, it is assumed that it is not a first-time user. The infobar is therefore only a part of the Data Catalog, its functionality is not connected with the `GMFrame` class, which represents the Layer Manager.

Pull Requests:

infobar in first situation: `https://github.com/OSGeo/grass/pull/1078`

infobar in second situation: `https://github.com/OSGeo/grass/pull/1183`

infobar in third situation: `https://github.com/OSGeo/grass/pull/1204`

8.3 Managament icons for vector and raster data import

Due to the infobar in the second situation, two management icons for data import are added. They are implemented in the file *gui/wxpython/datacatalog/toolbar.py* in the `DataCatalogToolbar` class and use images used for the same purpose in QGIS. Depending on the type of import (vector/ raster), the function called *Simplified vector import with reprojection (v.import)* or *Simplified raster import with reprojection (v.raster)* is called. These are the same functions that are linked to the buttons "Import vector data" and "Import raster data" in the infobar set for the second situation.

Pull Request:

`https://github.com/OSGeo/grass/pull/1205`

Figure 87: Management icons for vector and raster data import (Source: Personal collection)

9 Results

In addition to the created proposal on how to improve the current GRASS GIS startup mechanism (see subsection 6.2), the goal of this work is to propose and implement a special mode for first-time users (see sections 6.1, 8). Based on Survey 1 Part 2 and section 2, this mode was compiled. It consists of infobar which is created in Data Catalog each time the user starts GRASS GIS and it is only up to the situation what message is displayed. The infobar is finally displayed in three defined situations, which were already proposed in Survey 2 - for the first time after the first GRASS GIS startup, the second time when the first-time user creates a new location successfully, and the third time when the first-time user imports data successfully. During the work, the user can then close the infobar but in reality, it is only hidden and in another defined situation it may get visible again. The following lines use the software screenshots to present these three situations and highlight the changes from the design in Survey 2.

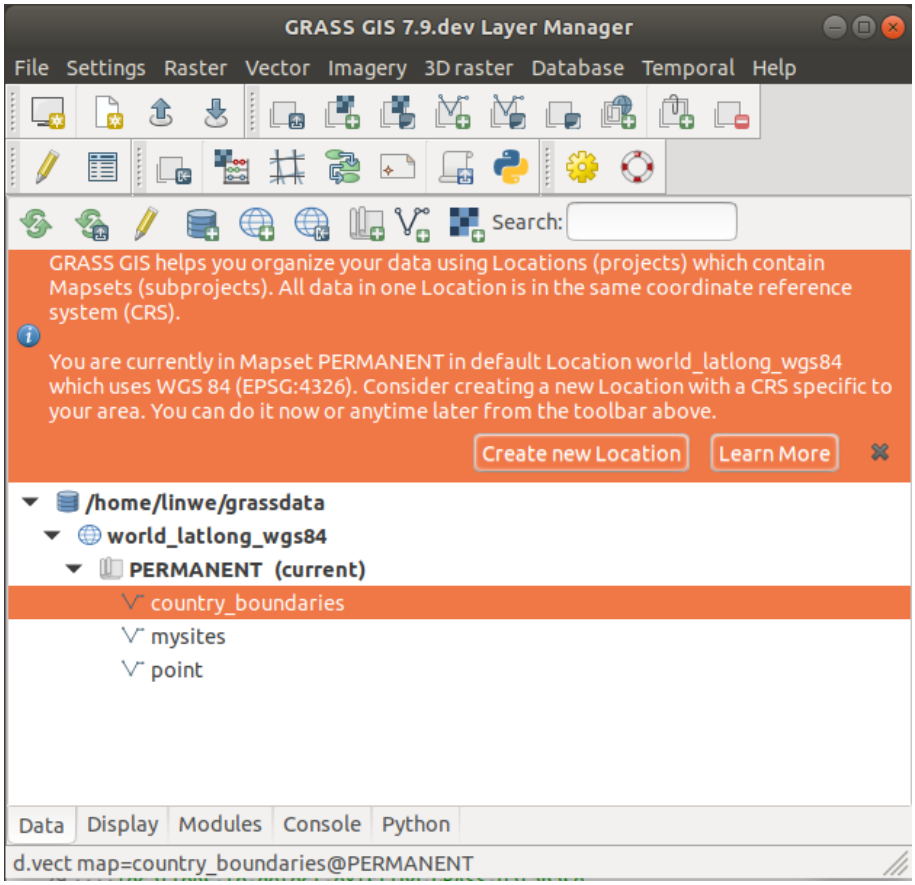


Figure 88: Layer Manager in Situation 1 (immediatelly after first startup) (Source: Personal collection)

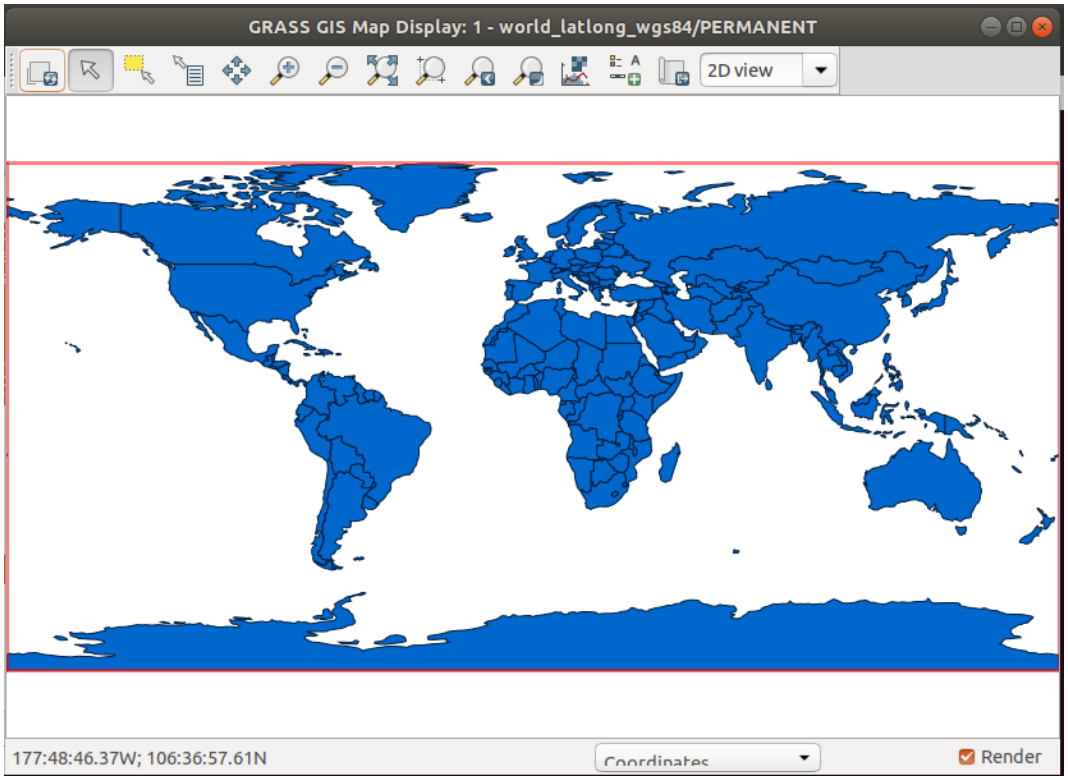


Figure 89: Map Display in Situation 1 (immediatelly after first startup) (Source: Personal collection)

Figures 88, 89 show the first situation in which every GRASS user finds themselves when start GRASS GIS after the installation. There are several important changes compared to the proposal in Survey 2 (see Figure 66). Firstly, the infobar is newly placed above the Data Catalog, which will help it not to be ignored. Secondly, the appearance of the infobar was slightly modified, which we can notice on the buttons that have different design. Thirdly, the color of the world map, which is displayed automatically as part of the demolocation, was changed to dark blue from the original gray. Lastly, the infobar text set for the first situation was slightly specified - the word " default " was added before the location name since there are responses in Survey 2 indicating that users do not understand where they are located.

In order to further improve the infobar function in the second situation, but also the Data tab in general, two management icons were created for the import of raster and vector data. We can see them in Figure 87 highlighted in red. The main reason is that management icons were very successful in Survey 1 Part 1 Question 3 and at the same time, the advice in the proposal in Survey 2 regarding File Manager is confusing since there are several functions for data import. It makes much more sense to continue with the same concept that was introduced at the content of the infobar in the first situation. Here, the creation of a new location is also possible via the management icon in addition to the button in the infobar. Therefore, the text of the originally proposed infobar in Figure 67 was slightly changed (see Figure 90).

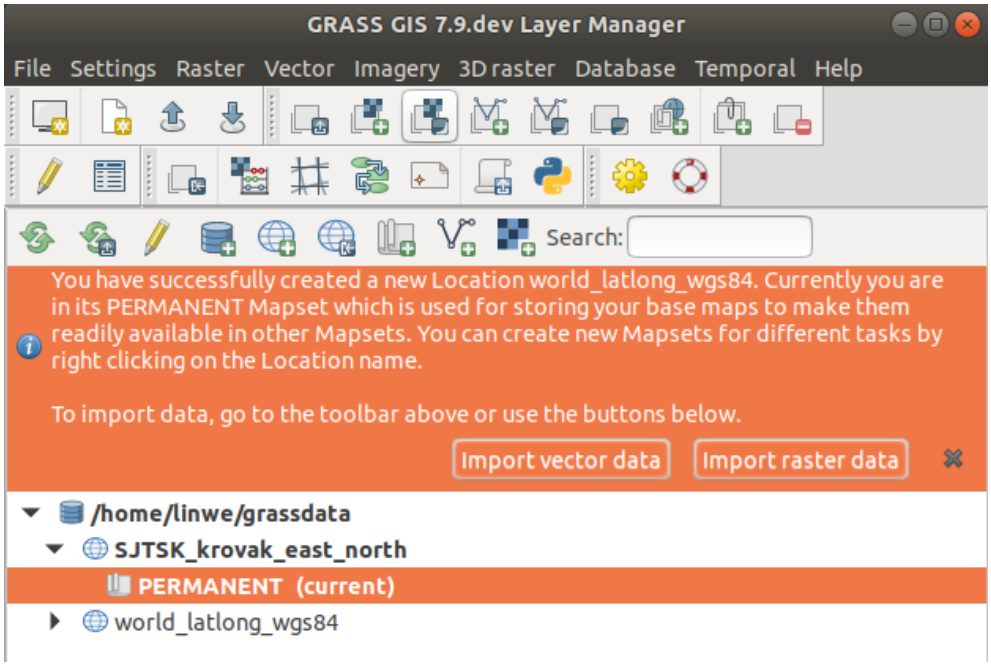


Figure 90: Layer Manager in Situation 2 (after successfully created location) (Source: Personal collection)

The originally proposed text in the infobar in the third situation (see Figure 68) was changed according to the proposal of the respondent #21 in Survey 2 Question 6. The Data tab after successful data import can be seen in Figure 91.

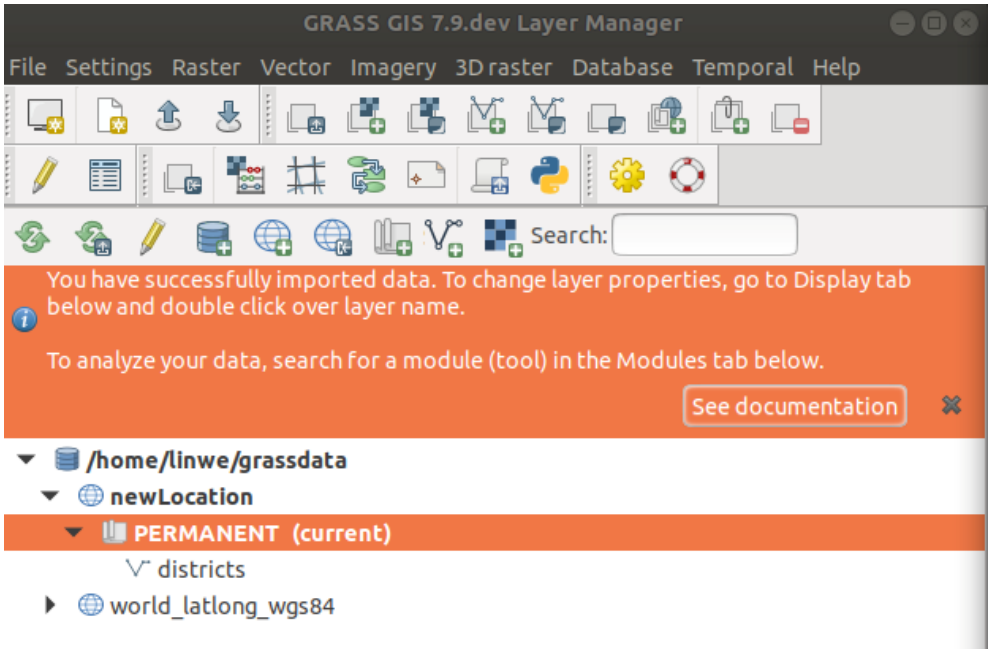


Figure 91: Layer Manager in Situation 3 (after successful import) (Source: Personal collection)

Discussion

This work's first important goal is to evaluate the benefits of significant changes that the author performed within the GSoC. Based on Survey 1 Part 1, it was found out that most users agree with the statement that partial removal of the startup screen and improvement of the Data Catalog simplifies the initial introduction to the software and further work. The most useful features according to users are the small icons in the Data Catalog distinguishing elements of data hierarchy, the new management icons for adding GRASS databases, locations, and mapsets, and for downloading sample locations, as well as new functions in the context menu for creating, renaming and deleting mapset and location.

Further direction of this master thesis is related to two key questions introduced in subsection 1.5. The first question – **How to enhance the first-time user experience?** – loosely follows the topic of improving the GRASS startup mechanism and seeks a way to get started in GRASS more user-friendly. The second question of this work – **How to improve the GRASS GIS startup mechanism?** – encounters the main shortcoming of the solution after GSoC, when the old startup screen (causing problems to first-time users) was not completely removed. In the following lines, the author describes how and whether these questions were answered at all as well as the shortcomings of the presented solutions and suggestions for improvements.

Based on the surveys and chapter 2, a first-time user mode extending the concept of the default location (location with pre-prepared data, into which GRASS will run at the very first start) was designed. This mode consists of three info messages, which are gradually displayed to the new user in defined situations. These user-intensive situations were determined based on Survey 1 Part 2. It turned out that users not only have trouble understanding the GRASS data hierarchy, but they also have problems with the meaning of Modules and Display tabs, and with data import. The advice that is provided in the info messages tries to address all three of these issues. The first message displayed to the user immediately after startup, in addition to the data hierarchy, also describes the concept of the default location. Key question number 1 was, therefore, largely answered. The evidence may be that in Survey 2 simulating the proposed solution of info messages, users in defined situations usually made the right decisions. Furthermore, there are comments among the open responses, which directly state that the person likes the proposal. Based on the second survey, the infobar was further enhanced by some of the topics raised in Survey 2. Therefore, It can be assumed that the version presented in chapter 9 is even more helpful from the user's point of view. However, this does not mean that the implemented solution cannot be improved. In the following paragraph, the author mentions several ideas for improvement.

The second survey shows that it is not entirely clear from the info message dealing with data import (see Figure 90) which functions the "Import vector data" and "Import raster data" buttons call. In addition to the buttons in the infobar, it is possible to use the newly implemented management icons for data import (see Figure 87), but the continuity of these functions may not be obvious at first glance. The improvement would mean adding images to the buttons (the same images that are used for management icons). Similarly, the first info message does not completely guarantee that the user will make the connection of the data hierarchy explanations (locations, mapsets) with the visual representation of the data hierarchy offered by the Data Catalog. In this info message, small icons could be placed in front of the data hierarchy elements' names, distinguishing which type of element it is. The text in info messages was slightly modified on the basis of Survey 2, but it can still be expected that its form can change. How the first-time user mode works will be shown by time and other users' suggestions.

As can be seen from the previous lines, most of the users like the idea of the infobar. In Survey 1 Part 1 Question 1, several suggestions were made that would solve the start of GRASS GIS when the last used mapset is not in a usable state by displaying a warning or an error message. A solution proposed for this issue conceptually improves and tightens the GRASS GIS startup mechanism introduced after GSoC. The second key question proposal incorporates both concepts on which the new first-time user mode stands - the concept of default location and the concept of info message. The concept of the default location is advantageous since, without a significant implementation intervention, it will enable the complete removal of the old startup screen, which still appears in the current implementation. The default location is used in the presented proposal in subsection 6.2 as an alternative solution, into which GRASS will start if the start to the last used mapset fails. In this case, the author suggests displaying the info message stating why the user is located in the default location. The work also suggests displaying info messages in other situations to speed up daily work with GRASS. The implementation of the proposal compiled for the second key question is not the goal of this work. However, the author assumes participation in these implementations after the completion of this work. Both the new first-time mode and the complete removal of the old startup screen are planned improvements to the new version of GRASS 8.0, which is scheduled for release in the spring of 2021.

In addition to the proposals and implementation of the first-time mode, this work brought a number of valuable answers concerning the further GRASS GIS development. For example, Survey 1 shows that starting GRASS using the file association of workspace file is not perceived by GRASS GIS users as essential, although it is standard in other software. There are also demands for better documentation. If we select the most important topics related to the GUI, users would especially like to simplify the path to import WMS/WFS, design GRASS GUI as a single window application, expand the set of management icons, and enrich the Data Catalog even more.

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A Help improve GRASS GIS startup mechanism and Data Catalog

Research: Help improve GRASS GIS startup mechanism and Data Catalog

Hello GRASS GIS users

Thank you for participating in our survey. Your feedback will help developers to create a better startup mechanism and Data Catalog. The results will be published as a part of a master thesis (https://github.com/ctu-geoforall-lab-projects/dp-kladivova-2021/).

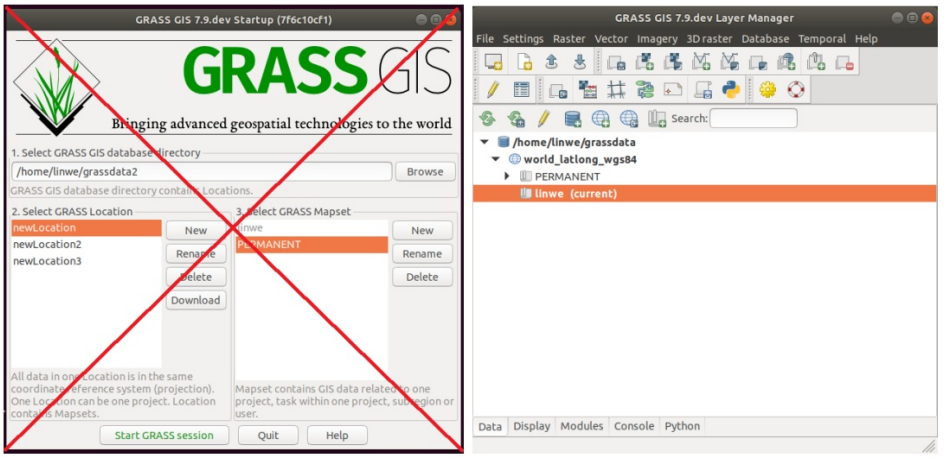
Research: Help improve GRASS GIS startup mechanism and Data Catalog

State of version 7.9 after GSoC

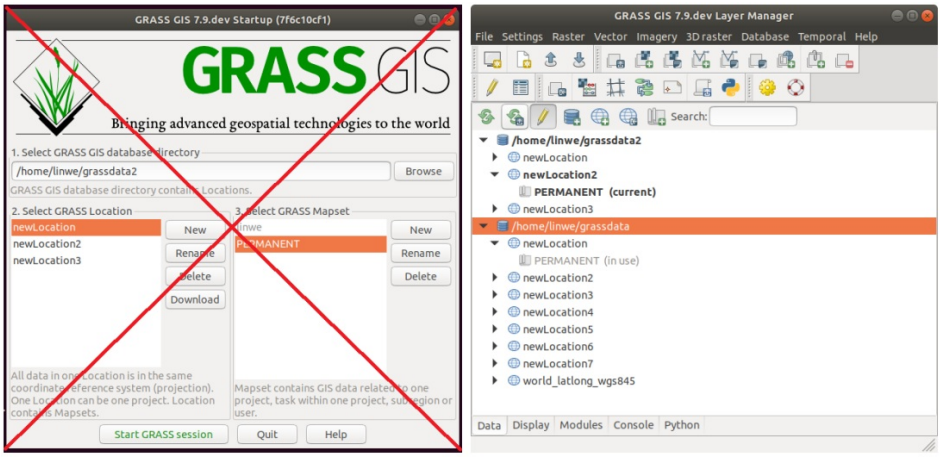
In the development version, the Data Catalog takes over all the functionality of the Startup screen including switching mapsets as well as locations and databases.

In the case of a first-time user, GRASS is launched directly with the Data Catalog visible in a prepared Demolocation. Similarly, GRASS bypasses the Startup screen if possible to start in the last used mapset. However, if a mapset is not in a usable state (was deleted or is used by another process) the Startup screen still appears.

So, we have no more startup screen for a first-time user:



As well as if possible to start in the last used mapset:



*** 1. What do you think about the following statement?**

The partial removal of the startup screen and improvement of the Data Catalog simplifies the initial introduction to the software and further work.

Strongly disagree — Strongly agree

*** 2. How do you think GRASS should start when the last mapset is not in a usable state (was deleted or is in use)?**

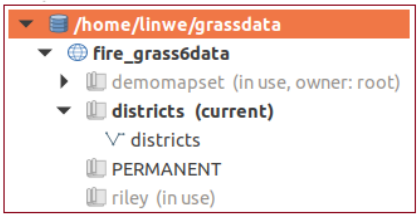
- ○ I suggest to bypass the startup screen and start in Demolocation.
- ○ I suggest to show a modernized version of the startup screen in this situation.
- ○ If not capable, please share your own idea:

We can see several changes concerning the Data Catalog. Within graphical changes, we can mention small icons distinguishing mapsets, locations, GRASS databases, and layers (vector, raster).
Or you might notice new Mapset access info (current, in use, and a different user).

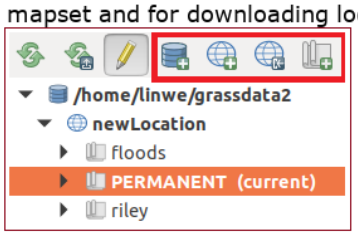
However, there are not only graphical changes but also new functions. We can manage mapsets, locations, and GRASS databases through context menus in Data Catalog. Or we can use for this purpose new management icons.

Let's have a look at all the new stuff:

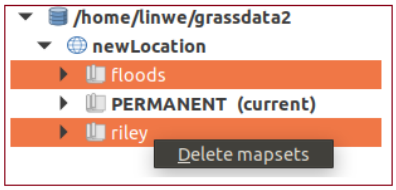
Mapset access info



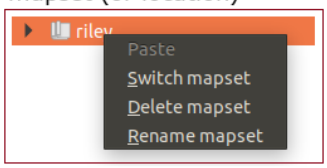
New management icons for adding GRASS database, location , and mapset and for downloading location



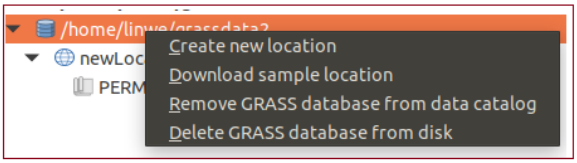
Deleting multiple mapsets (locations)



Creating, renaming and deleting mapset (or location)



Removing GRASS db from Data Catalog / Deleting GRASS db from disk



Adding multiple GRASS databases

*** 3. Please, rank how useful these features in Data Catalog would be (or already are) for you (1 = the most useful).**

Mapset access info (current, in use, and a different user)

Deleting multiple mapsets or locations

Adding multiple GRASS databases

Creating, renaming and deleting mapset or location

New management icons for adding GRASS database, location, and mapset, and for downloading location

Small icons distinguishing mapsets, locations, GRASS databases, and layers (vector, raster)

Removing GRASS database from Data Catalog / Deleting GRASS database from disk

*** 4. Which features would you like to add?**

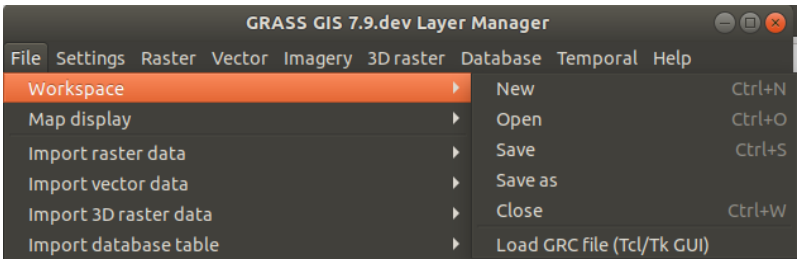
*** 5. Because we have limited screen space, we need to think about where we can add new features.**

Where would you add them?

- ○ To context menus in Data Catalog
- ○ To management icons
- ○ To both
- ○ I don't think any features should be added. There is little space for that.

In some software including QGIS, we can start the software using the file association.

In the development version of GRASS, we can use workspaces. However, the workspace file (.gxw) is not associated with GRASS, so we cannot start GRASS from File Manager.



*** 6. So, what do you think about the following statement?**

I would start GRASS using the file association of the workspace file (.gxw) frequently.

Strongly disagree — Strongly agree

B Help create a better first-time user experience in GRASS GIS

Research: Help create a better first-time user experience in GRASS GIS

Hello GRASS GIS users

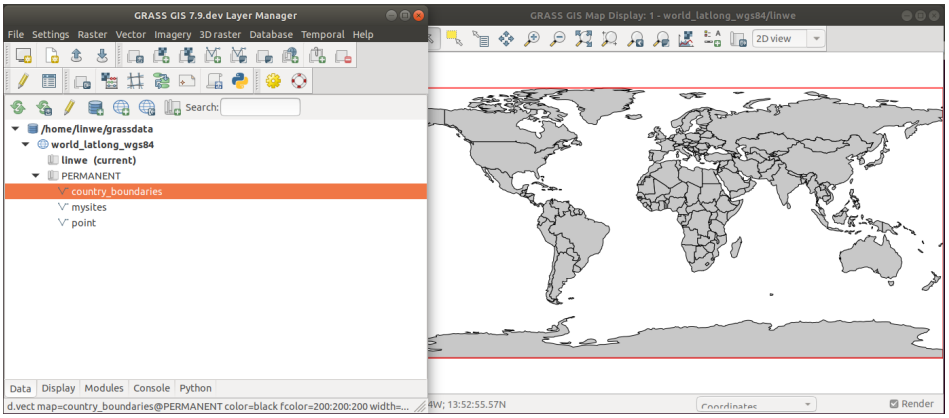
Thank you for participating in our survey. Your feedback will help developers in the decision on how to enhance the first-time user experience. The results will be published as a part of a master thesis (https://github.com/ctu-geoforall-lab-projects/dp-kladivova-2021/).

Research: Help create a better first-time user experience in GRASS GIS

State of version 7.9 after GSoC

For a first-time user, the current development version launches directly in demolocation called world_latlong_wgs84.

This picture serves as an example of the correct data organization. Original data are stored in a permanent mapset whereas already analyzed data belongs to another mapset, for example to the one named after a user.
The current implementation does not show a world map immediately at startup, it is necessary to display the map using Data Catalog.

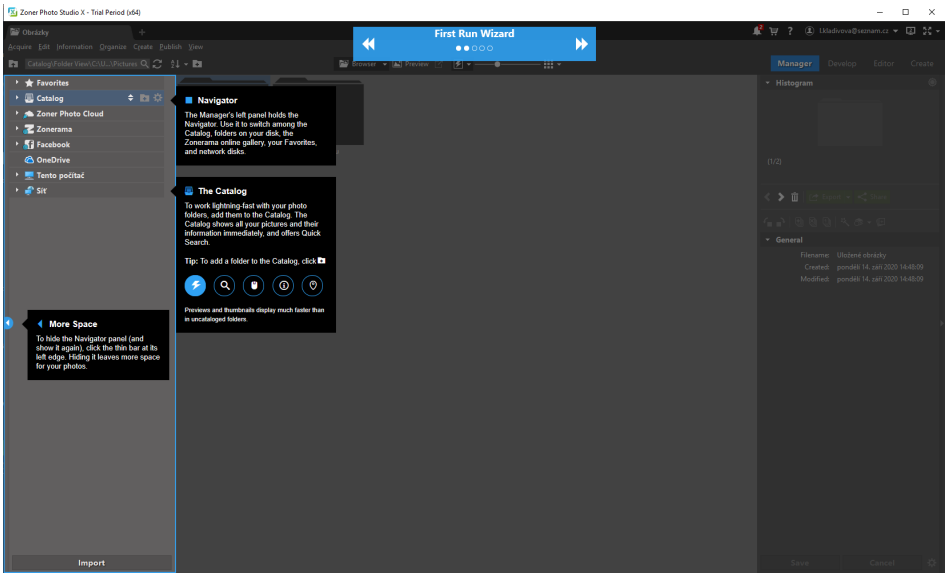


Developers are considering to improve the current solution by implementing a special mode for first-time users.

There are basically two options for what it might look like:

a) A first-time user would see info bars giving them advice. Those info bars are for example in QGIS and inform a user about projection transformation.

b) A first-time user would see the First Run Wizard which describes different parts of the software (we can see it e.g. in Zoner Photo Studio)



*** 1. Do you like the idea of First Run Wizard (inspired by Zoner implementation)?**

- ○ Yes
- ○ No, I think it's an unnecessarily complicated option
- ○ No, I think people will skip it anyway
- ○ Yes, but... (please specify)

*** 2. Do you like the idea of first-time mode info bars (visually similar to info bars in QGIS implementation)?**

- ○ Yes
- ○ No
- ○ No, I think people will ignore it
- ○ Yes, but... (please specify)

*** 3. Do you have other ideas that would lead you to a more straightforward navigation in the software?**

4. What software do you think does a good job of providing a good first-time user experience? *(optional)*

*** 5. Let's imagine you are a first-time user. What would help you significantly in your initial orientation in the software? Please, rank those features according to the importance (1 = the most important).**

- Description of main tabs (Data, Display, Modules, Console, Python) and Map Display
- Description of what GRASS database, location and mapset means
- Brief advice on how to start (e.g. how to create a new location and import data)

C Help improve the special mode for first-time users in GRASS GIS

Research: Help improve the special mode for first-time users in GRASS GIS

Hello!

Thank you for participating in this survey.

Your feedback will help developers to improve the proposed special mode for the first-time users which should enhance the initial user experience in GRASS GIS. The results of the survey will be published as a part of a master thesis (https://github.com/ctu-geoforall-lab-projects/dp-kladivova-2021/).

In order to fill in the survey, you don't have to install the software. It is not even necessary you know GRASS at all. We only assume a very basic knowledge of GIS.

All Figures you will see are suggestions that have not been implemented yet.

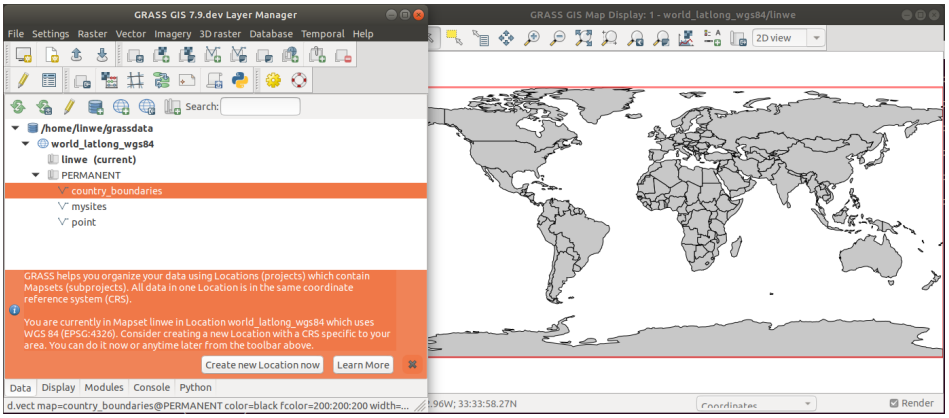
Research: Help improve the special mode for first-time users in GRASS GIS

Let's imagine a situation where you have **vector data of rivers in the Czech Republic in the shapefile format in the coordinate system S-JTSK / Krovak East North (EPSG: 5514).** You would like to import this data into GRASS and perform a simple task - **extract a river called Otava and save it in a separate layer.**

Research: Help improve the special mode for first-time users in GRASS GIS

Situation number 1

You download GRASS GIS. Once you run it, you will see the situation shown in Figure 1:



Take a close look at Figure 1 and answer the following questions.

*** 1. What will be your next step in this situation?**

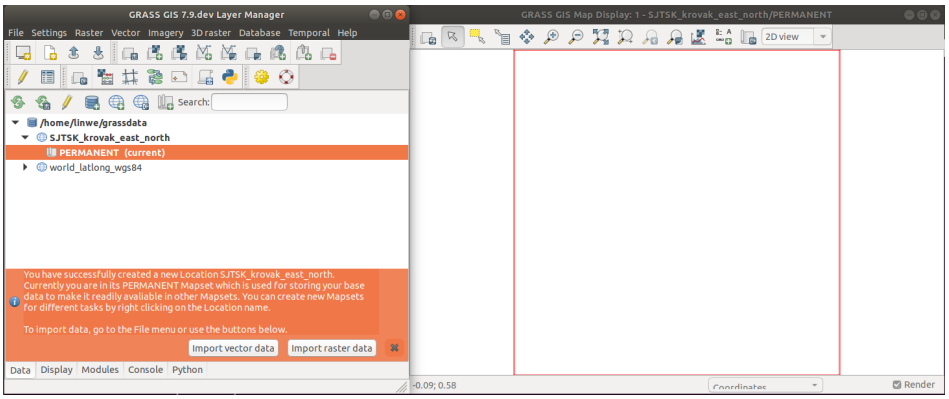
- ○ I will try to find a function to import data somewhere.
- ○ I will create a new Location.
- ○ I will create a new Mapset.
- ○ I will create a new GRASS database.
- ○ I will be confused what to do next and give it up.

2. Is something confusing to you? If so, what specifically?

Research: Help improve the special mode for first-time users in GRASS GIS

Situation number 2

Let's suppose you got to the situation captured in Figure 2:



*** 3. Take a close look at Figure 2. What will be your next step in this situation?**

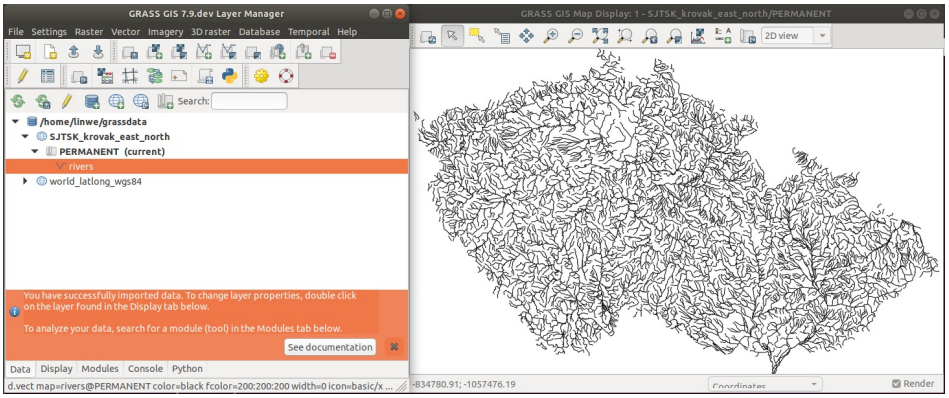
- ○ I will import data using *Import vector data* button in Info Bar.
- ○ I will create another Location.
- ○ I will import data through File menu.
- ○ I will be confused what to do next and give it up.
- ○ Other (please specify)

4. Is something confusing to you? If so, what specifically?

Research: Help improve the special mode for first-time users in GRASS GIS

Situation number 3

Let's say you managed to import data. The situation you are currently in is shown in Figure 3:



*** 5. Take a close look at Figure 3. What will be your next step in this situation?**

- ○ I will find the right function in the documentation and go to Modules tab.
- ○ I will go straight to the Modules tab.
- ○ I will be confused what to next and give it up.
- ○ I will find the right function in the documentation and go to Display tab.
- ○ I will go straight to the Display tab.
- ○ Other (please specify)

6. Is something confusing to you? If so, what specifically?

Research: Help improve the special mode for first-time users in GRASS GIS

*** 7. What do you think about the following statement?**
The advice in Info Bars given in each situation was straightforward and led me very well to the right answers.

Strongly disagree — Strongly agree

8. Any ideas you want to share? (e.g. the change of wording in Info Bars, adding more information, or, conversely, the removal of some information)

*** 9. What is your general experience with GIS?**

- ○ Beginner
- ○ Intermediate
- ○ Professional

*** 10. How often do you use GRASS GIS?**

Never used GRASS — Sometimes — Every day

Thank you for your responses!

By the way, the searched function is *Select by attribute* and the result of the task would be as follows :-):