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Evaluating Learnability and Accessibility of a Software for Engineers: Case of Model Server Manager (MSM) at Jotne

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Preface

This Master thesis makes up finale 60 credits of a two-year Master studies in Universal design of ICT at Oslo Metropolitan University. The study aims to evaluate learnability and accessibility of a software (Model Server Manager) developed by Jotne IT.

Foremost, I would like to extend my deepest gratitude to my supervisor, for extraordinary support and supervision throughout this research. Thank you for many productive discussions and advices during this study.

I would also like to direct a sincere thank you to all the informants for their participation in this research. Their contribution is the foundation of this thesis and without their participation it wouldn’t be possible.

Last, but not least, I would like to take this opportunity to thank my teachers, family, and friends who were there for me in a stressful time and believed in me.

Oslo, May 2018

Department of Computer science, Oslomet
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Abstract

Learnability and accessibility are fundamental aspects of every system. They are important qualities that make a system easily and quickly usable and understandable by new users as well as users with disabilities. There is a swift growth in the need of ICT-solutions that are learnable and accessible to everyone partly due to Convention on the Rights of Persons with Disabilities (CRPD) and country-specific anti-discrimination laws that require design of accessible ICT systems for all, including persons with disabilities. Beside compliance to the laws, designing products which are easily understandable and usable by larger group of users, including people with disabilities, would establish the competitive advantage of an organization. There have been usability and accessibility guidelines that could be used to ensure accessibility and usability of software and web-based systems. There have also been guidelines specific to learnability proposed by some researchers.

This study aims to evaluate learnability and accessibility of a software Model Server Manager (MSM) which is developed by Jotne IT, a company in Norway, and recommend solutions that could improve its learnability and accessibility in future updates of the software. The study used a combination of heuristic evaluation performed by the author and a developer of MSM followed by online interviews with the users of MSM. The data collected was analyzed through thematic analysis.

This research found some problems which could be related to the low-level adoption of accessibility guidelines and the requirements for universal design. Some of the problems are easy to fix while the others require some changes in organizational routines. The solutions recommended include development of organizational guidelines, development of heuristics which can be used by developers to ensure accessibility and learnability of future products, and competence development of programmers on accessibility and universal design, these measures could be helpful not only to MSM but also to other drafting tools which are used by engineers.

Key words: Universal design, learnability, accessibility, and Model server manager.

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List of Acronyms

EDM.	EXPRESS data manager.
MS	Model server.
MSM.	Model server manager.
UD.	Universal design.
IT.	Information technology.
ICT.	Information and communication technology.
UI.	User interface.
IFC.	Industry foundation classes.
CRPD.	Convention on the rights of persons with disabilities.
WCAG.	Web content accessibility guidelines.
WAI.	Web accessibility initiative.
BIM.	Building information modeling.
ITU.	International telecommunication union.
HCI.	Human computer interaction.

1. Introduction

The development and extensive use of information technology (IT) in the form of IT governance (Grembergen & Haes, 2007), online shopping (Wang & Yang, 2007), digital health support (Hanna, 2015), online learning services (Al-Rawi, 2013), online communication as well as digital economy has made our society dependent on IT (Marcus & Kara, 2015; Cámara & Tuesta, 2017).

Regardless of high dependency on IT, half of the world population does not have access to internet or IT services[1]. Mossberger, Tolbert, & McNeal (2007) underlined it as Digital Divide. Digital divide also occurs if information and communication technology (ICT) designs fail to address user diversity in terms of disability, culture, age and other factors. According to World Health Organization (WHO)[2] "15% of world population lives with some form of disability". For that reason, there have been guidelines for making ICT products accessible and usable for diverse groups of users. This paper is focused on studying accessibility and learnability (which are attributes of usability) of a software.

According to ISO standard 9126[3], learnability is "the capability of the software product to enable the user to learn its application". It is an aspect of usability and is of major concern in the design of software applications. Accessibility, as described by Petrie & Bevan (2009) refers to the quality of a system to be used by people with disabilities. It thus is concerned with accommodating the interaction needs of the older people and/or people with different forms of disability.

Accessibility and learnability of the user interface (UI) is crucial for the whole software to be easily and properly used by its users. Poor UI design results in high error rates, higher training costs and, as the result, affects the productivity of the overall organization. Thus, it is important to design software products so that they can be accessible and learnable to all users to the

[1] http://www.internetlivestats.com/internet-users/
[2] http://www.who.int/disabilities/world_report/2011/report/en/
[3] https://www.cse.unsw.edu.au/~cs3710/PMmaterials/Resources/9126-1%20Standard.pdf

extent possible. This research is started by acknowledging the facts discussed above to evaluate learnability and accessibility of EXPRESS Data Manager Model Server Manager (EDMMSM or MSM), a product of Jotne IT[4]. The Jotne group is a privately held investment organization established in 1982. They are engaged in different areas such as oil and gas, mechanical industry, information technology, aeronautics and real estate. As part of their IT related activity, they have developed a suite of model-driven database systems called EXPRESS Data Manager (EDM). EDM is a database server based on EXPRESS data modeling language[5]. It is mainly used for the import and export process of industry foundation classes (IFC) models. The Model Server Manager (MSM) is the UI component of the suite for viewing the surfacing, geometry, and reporting on the related information (Further discussed in Section 1.5.2)

Besides the obvious importance for broadening the appeal of products to wider range of user groups, learnability and accessibility are required qualities of ICT products according to international conventions and country-specific laws. For instance, Convention on the Rights of Persons with Disabilities (CRPD)[6] requires ICT systems to be accessible for persons with disabilities. The European Accessibility Act[7] also recommends for products and services in European Union to be more accessible to, persons with disabilities. This Act was proposed on 2nd December 2015 and it is expected to become a binding law. Regardless of the laws or conventions, learnability and accessibility are crucial qualities for survival of a system. People abandon a system if it is difficult to use. Efforts need to be made to help users easily and instantly use a system without spending much time on reading its documentations or figuring out intricacies on the UI. There could be lots of alternative software's in the market. Therefore, learnability and accessibility of a software establish its competitive advantage. Besides that, it would require time, energy, and cost to train new users if a software is complex to use. Thus, designing accessible and learnable systems could help to reduce training costs.

[4] http://www.jotneit.no/

[5] http://www.jotneit.no/images/pdf/EXPRESS_White_Paper.pdf

[6] https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

[7] http://www.edf-feph.org/european-accessibility-act-1

As mentioned above, the aim of this research is to evaluate learnability and accessibility of MSM. It involved heuristic evaluation and online interviews to identify the problems confronted by users of MSM and provide valuable recommendations for its improvement.

The rest of the paper is organized as follows. First, the main concepts used in this research are defined and presented, followed by a background information which explains the research area and the research questions. Then, review of related research is presented, followed by the explanation of the methods used in the research. Then, the results are presented followed by a discussion of the results. Finally, the paper closes with conclusion and recommendations for further improvement of MSM.

1.1 Universal design

According to CRPD[8], universal design (UD) is "the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. "Universal design" shall not exclude assistive devices for particular groups of persons with disabilities where this is needed". Ronald L. Mace[9] defined UD as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design". There seems an admission for the fact that UD requirements would require sacrificing some aesthetic aspects of products and facilities to make them usable to everyone.

According to the Norwegian anti-discrimination and accessibility act[10], UD is "designing or accommodating the main solution with respect to the physical conditions, including information and communications technology (ICT), such that the general functions of the undertaking can be used by as many people as possible, regardless of disability."

Persson et al, (2015, p.524) defined UD as "the extent to which products, systems, services, environments and facilities are able to be used by a population with the widest range of

[8] http://www.un.org/disabilities/documents/convention/convention_accessible_pdf.pdf

[9] https://www.uwyo.edu/wind/_files/docs/resources/ud_review.pdf

[10] https://lovdata.no/dokument/NLE/lov/2017-06-16-51/KAPITTEL_3#KAPITTEL_3

characteristics and capabilities, to achieve a specified goal in a specified context". UD is also defined as "All people, particularly disabled and older people, can use websites in a range of contexts of use, including mainstream and assistive technologies; to achieve this, websites need to be designed and developed to support usability across these contexts" (Petrie et al, 2015, p.3).

Critics said that UD is overly ambitions with a goal impossible to attain especially in interactive systems (Harper, 2007; Wobbrock et al., 2011). However, UD could be used as a reminder for the fact that there are user groups who have difficulties in using products and services due to their disabilities and other cultural or language barriers. Thus, UD could be understood as "a goal that puts a high value on diversity, equality, and inclusiveness. It is also a process" (Burgstahler, 2009, P.1).

1.2 Usability

According to Nielsen[11], "usability is a quality attribute that assesses how easy user interfaces are to use. The word usability also refers to methods for improving ease-of-use during the design process". Five qualities of usability defined by Nielsen are:

- Learnability: The ease a system offers for new users to quickly learn it and accomplish basic tasks on it.
- Efficiency: how fast users perform basic tasks after learning the system.
- Memorability: When users come back to the system after some period of nonuse, how easy is for them to recall their expertise.
- Errors: How many errors do users make, how intense are those errors, and how easy it is for a user to recover from those errors.
- Satisfaction: how satisfied users are when using the system.

Bevan, (1995, p.1) quotes ISO 9241-11 to define usability as "the extent to which a product can be used by specified users to achieves specified goals with effectiveness,

[11] https://www.nngroup.com/articles/usability-101-introduction-to-usability/

efficiency, and satisfaction in a specified context of use". usability is dependent on the context of use, which includes users, tasks, equipment, and environment. This is illustrated by the ISO usability framework shown in Figure 1-1. ISO Framework of usability (ISO 9241-11, 1991)

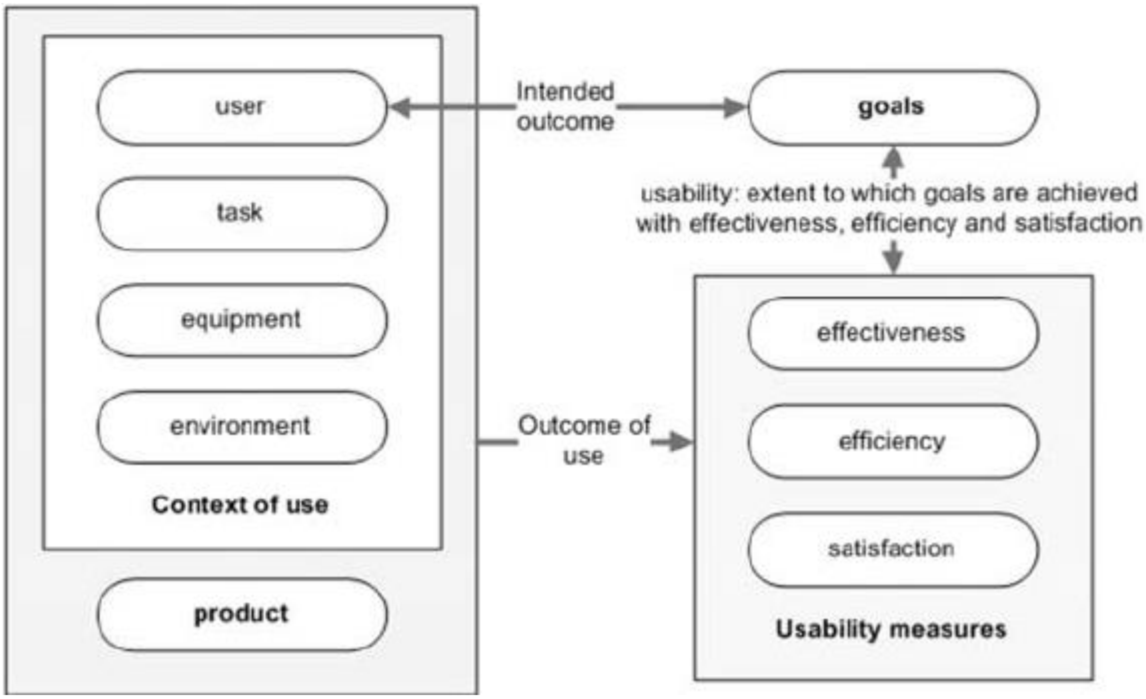

Figure 1-1. ISO Framework of usability (ISO 9241-11, 1991)[12].

Usability is summarized as 'Ease-of-Use of a system'. The term was introduced in early 1980's with a determination to replace the term 'User Friendly' (McNamara & Kirakowski, 2006). A study conducted displayed that for better usability of a system, it is required to be taken care of these four attributes, such as User, Task, Tool, and environment (Shackel & Richardson, 1991). Usability of a system can be determined by the ease of use of that system it provides to its users. Usability Is not only limited to interaction between users and software's. it also provides other aspects as well, Including data, metadata, computer systems and networks (Dubey & Rana, 2010).

[12] http://www.usability.ru/sources/iso9241-11.htm

All usability characteristics are useful for developers and users of the system to realize that a system is useable (Thomas, 2003). The achievement of intended goals can measure usability of a system. Dillon (2002) pointed that usability is about user's satisfaction and performance of the system. However, it might have changes in desirable levels of effectiveness.

1.3 Learnability

Laakkonen (2006, p.24) claims that, "literature does not appear to present a generally accepted model of learnability. There is also an enormous amount of research on human learning, but its relationship to learnability is almost totally lacking". Grossman et al, (2009) defined learnability as the quality of being learnable. Michelsen et al, (1980) said that a system should be easy to learn by the class of users for whom it is intended. Referring to Nielsen (1994), Grossman et al (2009, p.650) explained learnability as "allowing users to reach a reasonable level of usage proficiency within a short time". By selecting a user who is new to a system and measure the time it takes them to learn the basic tasks of the system is learnability (Nielsen, 1994). "Learnability concerns the features of the interactive system that allow novice users to understand how to use it initially and then how to attain a maximal level of performance" (Dix et al. 2004, p.261)

Santos & Badre (1995) elaborated it as, the effort required for a novice user to perform basic tasks on a UI of a system. Holzinger (2005) represented learnability as, allowing users to quickly begin to work with the system. Rieman (1996, p.1) studied and explained learnability of a system as "minimally useful with no formal training". The time and effort required to be able to perform specified functionalities of a system is learnability (Gould & Lewis, 1985; Shackel & Richardson, 1991; Stone, Jarrett, Woodroffe, & Minocha, 2005). "The learnability of a design is based on comprehensibility: if you can't understand it, you can't learn it" (Heim, 2008, p.12).

Grossman et al, (2009) stated that, the type of users, for which learnability is important are specified as, unexperienced users or novice users. They can be divided into two groups experienced and unexperienced. They also mentioned that there is no completely accepted definition of learnability. Interface usage requires learning, there is a clear acceptance that learnability is an essential and most fundamental attribute of usability (Abran et al, 2003; Nielsen, 1994). From the definitions and explanations presented above, learnability could be understood as a quality of a system that allows users to understand its features, functions and design will little effort and time to start working on it. Learnability is among several qualities desired from a system. As depicted by Mifsud (2011)[13] below with Figure 1-2. External and internal qualities of a system, (Justin Mifsud, 2011)and Table 1-1. Objectives of the sub characteristics of usability, (Justin Mifsud, 2011)., it constitutes part of desirable internal and external qualities of a system.

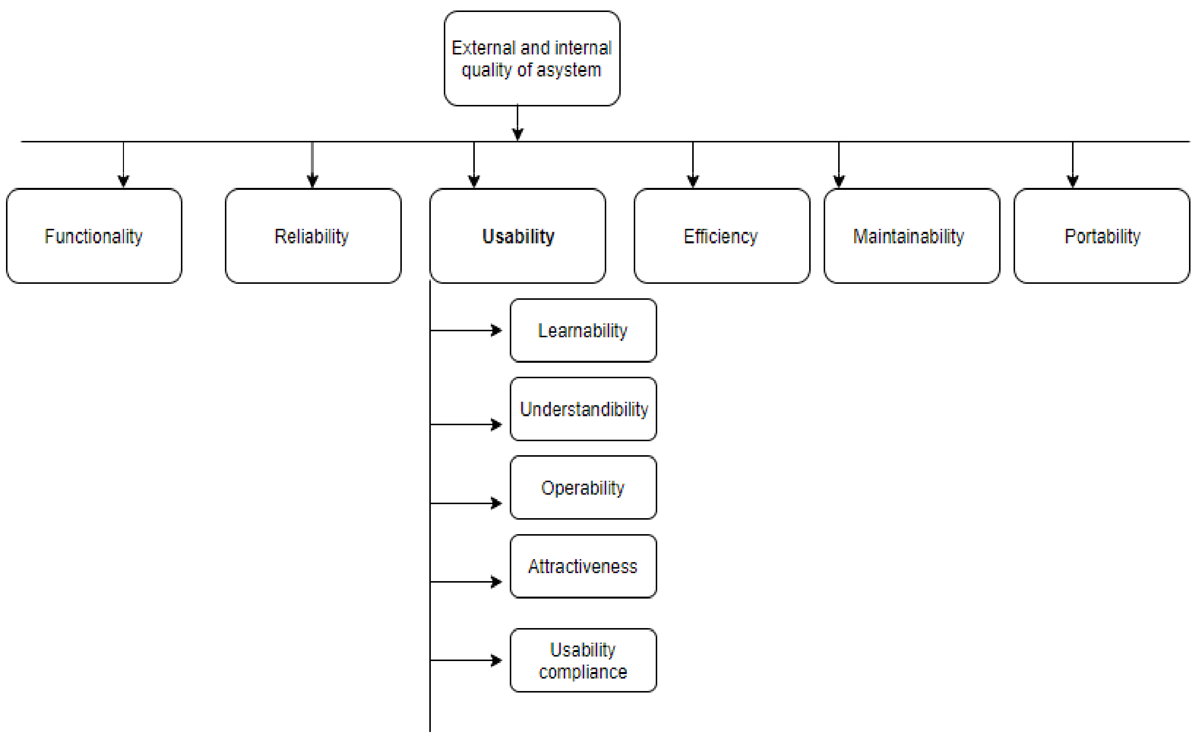

Figure 1-2. External and internal qualities of a system, (Justin Mifsud, 2011)[14].

[13] https://usabilitygeek.com/the-difference-and-relationship-between-usability-and-learnability
[14] https://usabilitygeek.com/the-difference-and-relationship-between-usability-and-learnability/

Table 1-1. Objectives of the sub characteristics of usability, (Justin Mifsud, 2011)[15].

Usability characteristics	**Objectives**
Learnability.	To learn.
Understandability.	To understand.
Operability.	To operate/Control.
Attractiveness.	To be attractive.
Usability Compliance.	To adhere.

1.4 Accessibility

At first, the arrival of IT enabled people to accomplish different tasks. It still does, but the problem arose is that most of them are inaccessible by persons with disabilities. As technology is evolving continuously the IT systems are becoming more exclusionary, unless we consider accessibility.

Waddell et al, (2003) underlined that, usability has subsets and accessibility is one of them and the accessibility issues faced by users are also usability issues of that system. According to Web Accessibility Initiative (WAI) "accessibility means that people with disabilities can perceive, understand, navigated and interact with the web and that they can contribute to the web. Web accessibility also benefits others, including older people with changing abilities due to ageing"[16]. Accessibility also depends on personal experience, sometimes an application can be accessible for one user while inaccessible for other.

As Tim Berners-Lee, world wide web consortium (W3C) Director and inventor of the world wide web, said, "Accessibility is essential for developers and organizations that want to create high quality websites and web tools, and not exclude people from using their products and services." Petrie & Kheir. (2007, p. 398) said that, "Accessibility can be defined as the lack of accessibility problems". They also mentioned that accessibility not only disrupt persons with disabilities, but

[15] https://usabilitygeek.com/the-difference-and-relationship-between-usability-and-learnability/
[16] https://www.w3.org/WAI/

it also creates barriers between non-disabled users and systems. So, during interaction with a system the less accessibility problems encounter by a user the more accessible is the system.

The qualities and capabilities of a product that makes it useable by wide range of user group are accessibility features of a system, either directly or in conjunction with assistive technologies. Although accessibility typically addresses users who have a disability. The systems that achieve fulfillment of higher accessibility guidelines are more accessible.

Waddell et al, (2003) believes that accessibility problems and usability problems are different because usability issues effect all users. Oppositely, accessibility issues only effect those users who have some limitations (Disabilities). Referring to web accessibility initiative (WAI)[17], In human computer interaction, computer accessibility (also known as accessible computing) refers to the accessibility of a computer system for all people regardless of disability or severity of impairment. The term accessibility is most often used about specialized hardware, software, or a combination of both. It is Designed to enable use of computer by a person with disability or impairment. Specific technologies may be referring to assistive technology. Most commonly used assistive technologies are, screen reader, braille keyboard, screen magnifier, voice recognition, hearing aids, eye tracking, and closed captioning[18].

Accessibility can be a reason for the success of a system. If a system is accessible by most number of users, it means it will have more users than the one which is not completely accessible. "Accessibility simultaneously describes two processes: first, the ability of the user to access information electronically; and second, the efforts made by the designer to enable a page to function with the assistive devices used by individuals with disabilities" (Foley & Regan, 2002, p.2). The most common and obvious dimension when discussing disability issues is accessibility to the physical environment, ICT systems, and others. From the definitions of accessibility, this study elaborates four major steps to be considered by the developers for the

[17] https://www.w3.org/WAI/fundamentals/accessibility-intro/
[18] https://webaim.org/articles/motor/assistive

achievement of an accessible system. Which are meaningful, understandable, predictable, and for everyone. Represented in the accessibility framework by author:

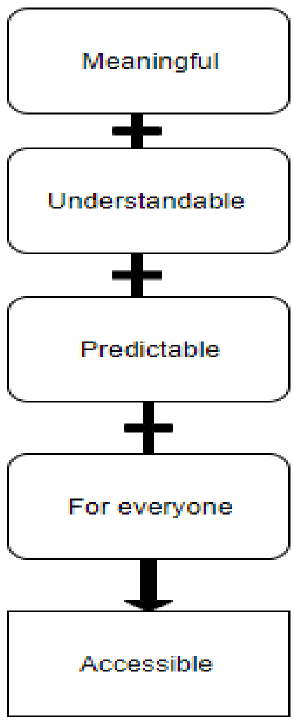

Figure 1-3. Accessibility Framework.

Accessibility and learnability are important due to number of reasons. It serves to give access to the individuals with disabilities in ways that were not previously possible. Second, they are legislations and applicable to many institutions. Third, accessibility offers assistances for all users by creating more usable systems. Fourth, learnable and accessible designs are based on more updated architecture and design that provides greater flexibility. Fifth and finally, they indicate an increase in the need of ICT systems.

1.5 Background

Jotne IT claims to be the leader in product data exchange and sharing, development of standards- based software products, Product data exchange, Product life cycle management, Long- term data & product archiving, data validation & verification, code checking, rules-based data modeling and cross-platform data sharing. Jotne IT aspires to reduce development and product lifecycle costs using intelligent data management in the areas of defense, Aeronautics, oil & gas, built environment and aerospace. Their product EDM is a suite of model-driven database systems that offers data interoperability solution for data exchange, data sharing, data integration and data archival. EDM implements the methodology of ISO 10303 standard for the exchange of product model data (STEP) [19]. ISO 10303 is responsible for identifying language in which product data can be presented and the language is called EXPRESS. Jotne IT has been developing STEP ISO 10303 product data exchange software products since 1994.

1.5.1 Express Data Manager and Model Server (EDM & MS)

Express Data Manager is an object-oriented database management system to support all the information relevant to a product's design and operations. This includes an enormous collection of data formats, applications, users, and processes. It is based on EXPRESS data modeling language and a standard for the computer interpretable representation and exchange of product manufacturing information. The goal is to support all open and recognized industry standards using the methodology and standards published by ISO 10303[20].

Building smart standards are used to configure the system in case of building information modeling (BIM) or virtual design and construction (VDC) use cases. "BIM is an intelligent 3D model-based process that gives architecture, engineering, and construction professionals the insight and tools to more effectively plan, design, construct, and manage buildings and infrastructures"[21]. VDC is basically creating the entire project virtually before it is really created. VDC is beneficial because of low risk, it minimizes the cost of the project, and remove contradictions.[22] Software's that are related to VDC are Revit, Microsoft project, Primavera, and Navisworks.

[19] http://www.jotneit.no/images/pdf/EXPRESS_White_Paper.pdf
[20] https://www.steptools.com/stds/step/
[21] https://www.autodesk.com/solutions/bim
[22] http://www.civilfx.com/virtual-design-construction-vdc/

BIM and VDC does not have major difference, but they are not completely same. Data insertion related to 3D modeling and physical objects is responsibility of BIM. However, VDC uses BIM models to schedule the process of construction from the beginning till end[23]. EDM offers functionality for all four domains. One may use it to build data translators/converters from one data format to another one, where one of them may be, but does not need to be an international standard, such as, ISO 10303 STEP or project life cycle support (PLCS). PLCS is an open international standard and it is used for product maintenance and support. It is an ISO standard, developed to insure ability of data transfer between systems and to secure, maintain and make data available throughout the life cycle of data. It is an extensive data model and users can select their appropriate parts of use.

One may apply EDM to share sources into one joint data model, for example into PLCS or you may want to store your data for a long time in a durable open and standardized data format. EDM is implementing interoperability for the design and operational life of a product, supporting work processes for data quality, retention, and others. According to Jotne EDM implements fully the methodology of ISO 10303 (STEP) and is the tool of preference for international open standards, such as STEP, PLCS, building SMART, POSC/CAESAR and others. Flow chart of different functionalities performed by EDM are presented in Figure 1-4. Flow chart of Express Data Manager (EDM).

One of its key functionality is that it is capable of consolidating and validating construction data received from different sources and to merge them into one model. This can be one constant merged model or merged on demand for report purposes. EDM is used to import/export, merge, and versioning of IFC models. IFC makes it possible to hold and exchange relevant data between different software applications. It is an international standard used to describe and exchange construction and facility management information. As a data format IFC is neutral and it is one of five types of open standard in the building smart portfolio that each perform different functions when it comes to the delivery and support of assets in the built

[23] http://www.civilfx.com/virtual-design-construction-vdc/

environment. Using IFC means that the construction professionals can use the software application(s) of their choosing to work with data. 150 applications around the world support IFC.

Different plugins are used to perform several operational tasks. Jotne IT have a pilot customer in Tonsberg using EDM to register issues and tasks directly into the model in a project phase. They also have a third-party partner that create software to generate online real estate portfolios and others.

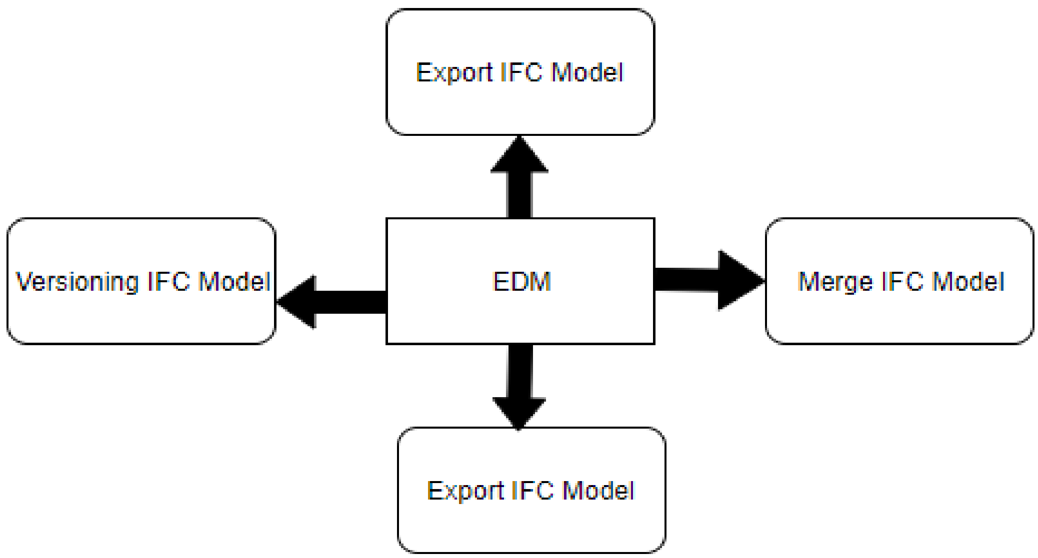

Figure 1-4. Flow chart of Express Data Manager (EDM).

EDM Server is managed by Jotne IT, it provides data and methods which can be accessed through extensive API and web services- or through MSM desktop coordination package. They are responsible for providing standard methods for 4D time/ schedule, 5D estimating/ cost planning, 6D sustainability/ energy/ LEED, 7D facility management.

The EDMmodelServerManager, henceforth referred to as MSM, is the graphical UI client to EDMmodelServer™ with integrated 3D viewing and reporting capabilities such as, merge, check out, validate model, and execute methods. The first version (3.3.4) of MSM was released on 5th July 2016. So far, Jotne has made eight versions of MSM. The latest version (3.4.0) was released on 29th November 2017. Mainly, end users of MSM are engineers/project managers and facility managers.

1.5.2 Model Server Manager (MSM)

In this section, MSM is explained briefly by displaying figures of related tasks. As mentioned, not all functionalities of MSM are discussed and evaluated. Since, the knowledge of author related to MSM is not of expert level. First, by launching MSM application a logon window is appeared, users must enter their credentials (user name, password, Role, Server host, Port number) in that logon window. It connects the user to the server or local connection depending on user's selection. Account management can only be performed by super users of the system. User can test the connection by pressing the test button or they can simply logon by clicking the logon button. In Figure 1-5. MSM server logon user Interface window and in Figure 1-6. MSM Local Logon User Interface window. are presented.

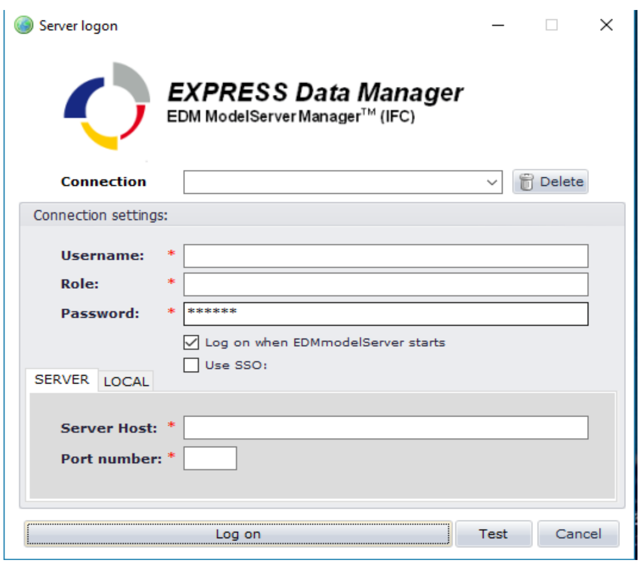

Figure 1-5. MSM server logon user Interface window

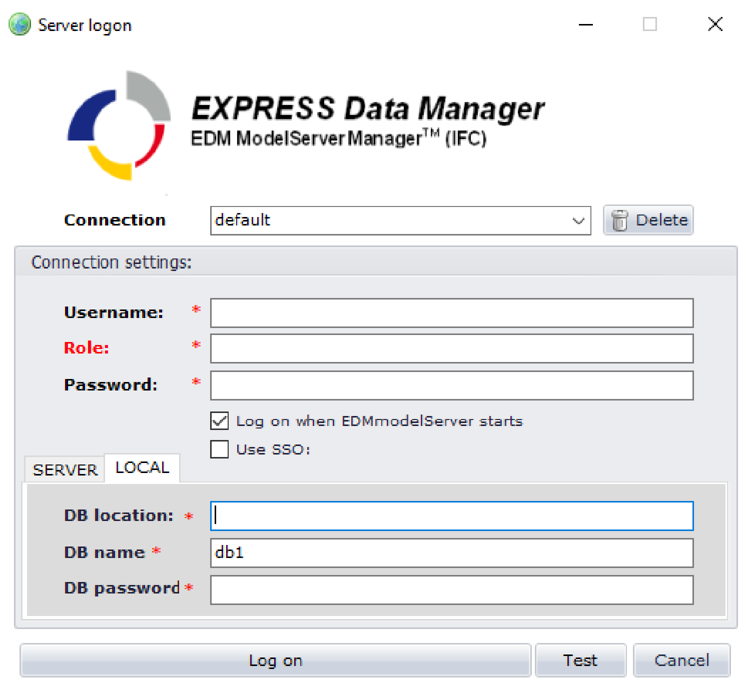

Figure 1-6. MSM Local Logon User Interface window.

Main Menu. After inserting user information and logging into the system main menu of MSM appears. It is a simple UI which is by default full screen and consist of a ribbon on top of the screen. It consists of five (5) tabs such as, File, Tools, view, plugins, and about. MSM allow its users to change language from a drop-down list on the top right of the main menu

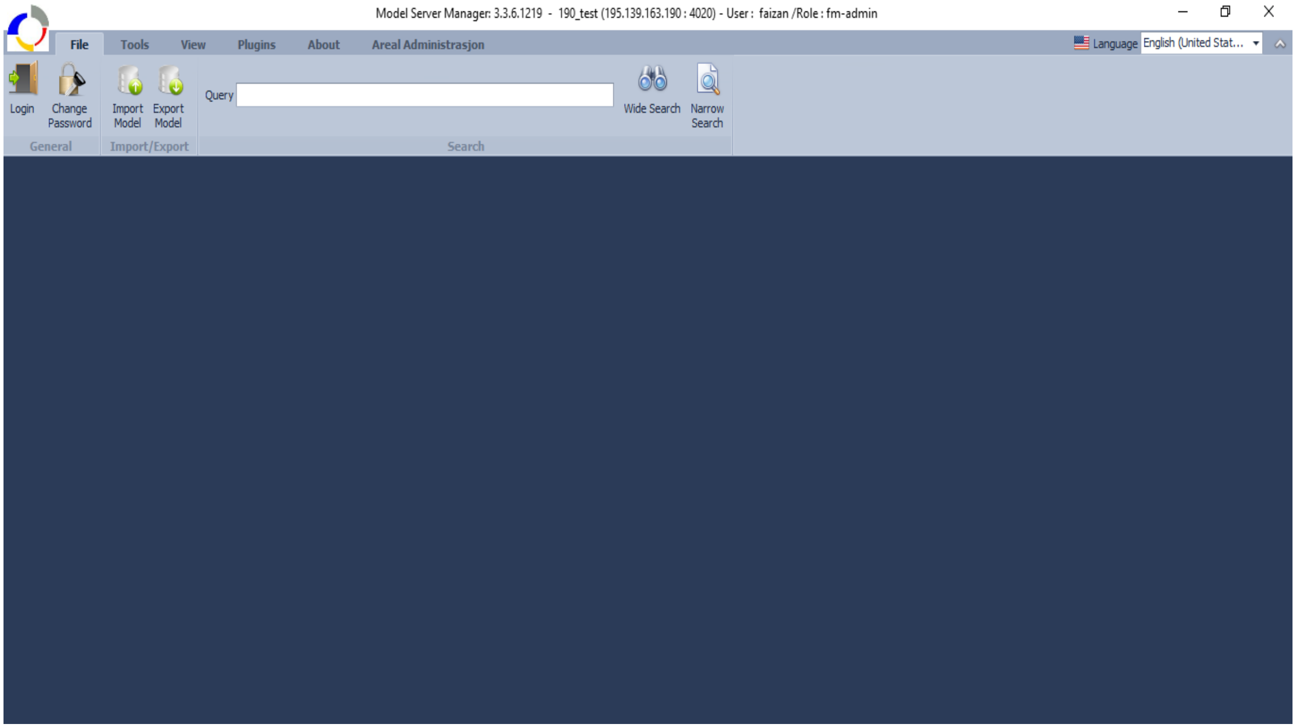

Figure 1-7. Main menu layout of MSM.

File. The first tab of MSM ribbon is file. Its sub menus consist of login, change password, import model, export model, wide search, and narrow search.

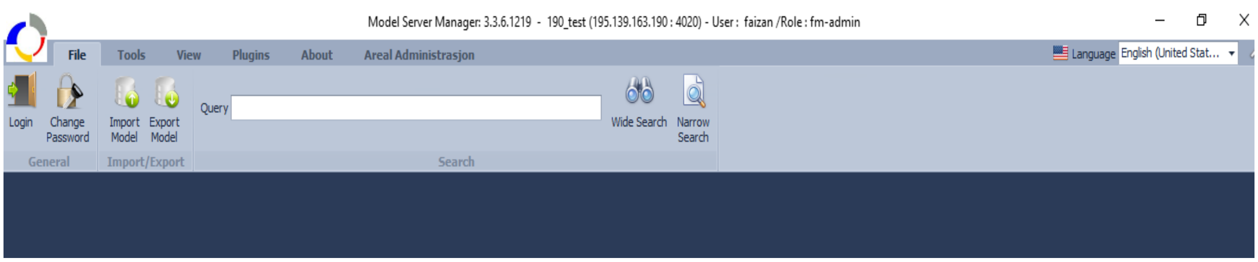

Figure 1-8. User interface of Drop down menu File in MSM.

Login option allow the user to login from another user account and logout from the already logged on account. Change password sub menu allow users to change their existing password to any new password.

Figure 1-9. Change password prompt message in MSM.

Import model and export model menus are used to import and export different IFC models in both STEP and XML formats. They can be accessed from project explorer as well. For performing import or export task users must select an appropriate project and type in industry, discipline, status, and author. All these fields are mandatory to be filled appropriately because MSM has version control functionality. So, the version will only increment if the above criteria are met otherwise the model will be imported as a new and different model.

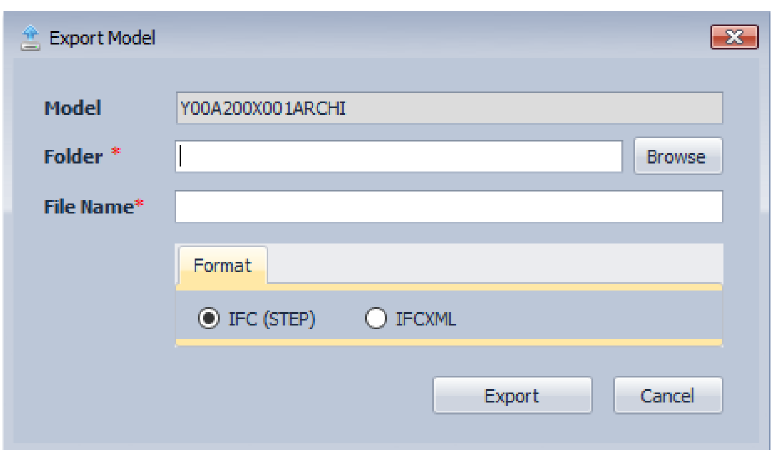

Figure 1-10. Export model window in MSM.

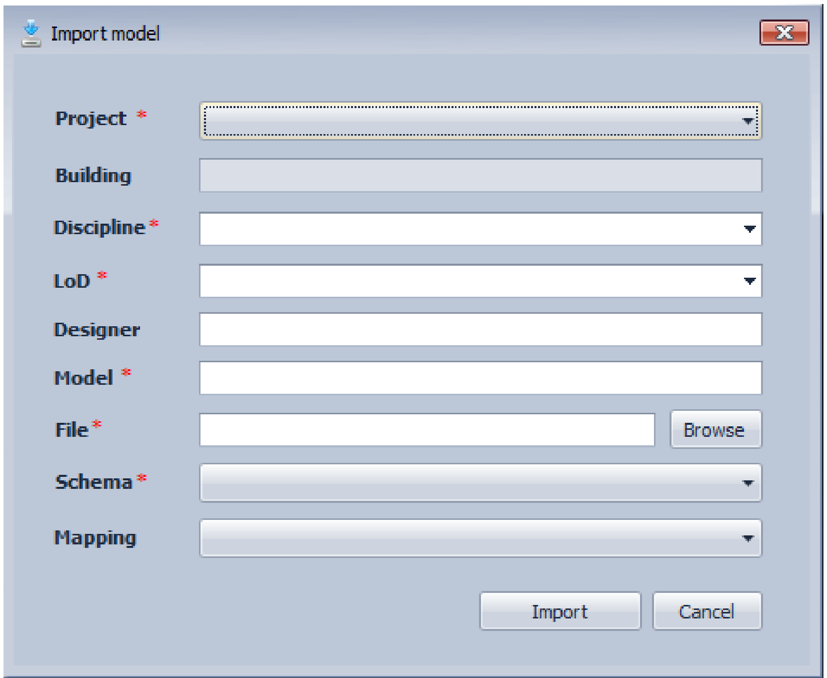

Figure 1-11**.** Import model window in MSM.

Tools. In MSM, users can build custom reports using drag and drop feature and advance express based functions. Functionality of reports offers the ability to view the report reflecting the collected models currently loaded in MSM viewer and the model explorer. By clicking the reports management from tools tab menu users can see report details, edit access settings for reports, and assign to objects.

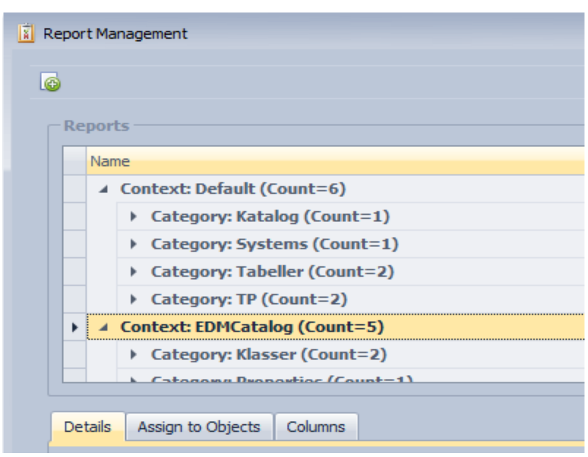

Figure 1-12. Report management window in MSM.

Access of any group/ user can be removed from the report by selecting the group/user and clicking on remove button. Users can also use unit conversation feature under tools tab. If users wish to see modified units in the properties window 'unit conversion on' must be checked from unit settings.

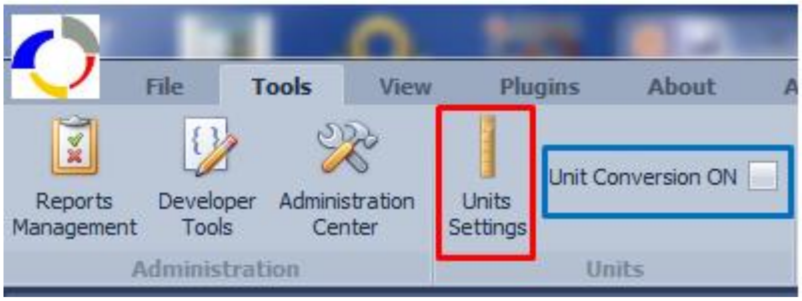

Figure 1-13. User interface of tools menu in MSM.

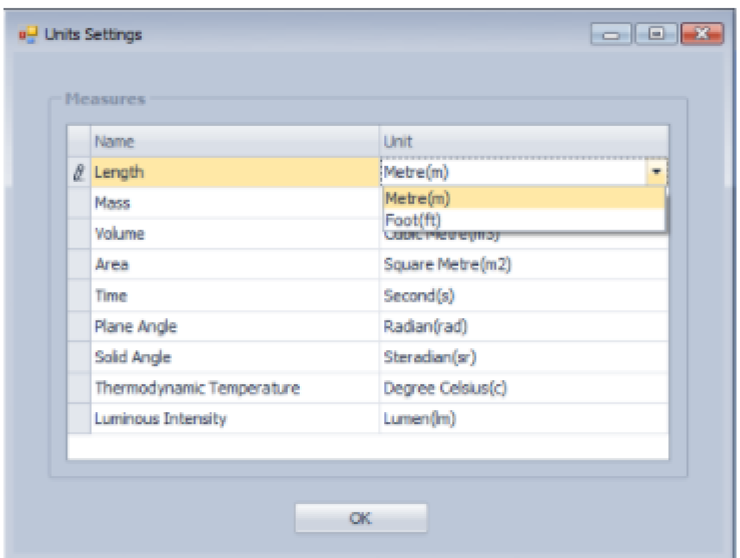

Figure 1-14. User interface of Unit settings in MSM.

View. MSM allow its users to access reload last saved, default layout and viewer functionalities from view menu. Last saved functionality is used to load last saved customization of windows layout and restore all component windows. Default layout is used for standard layout created by the developer.

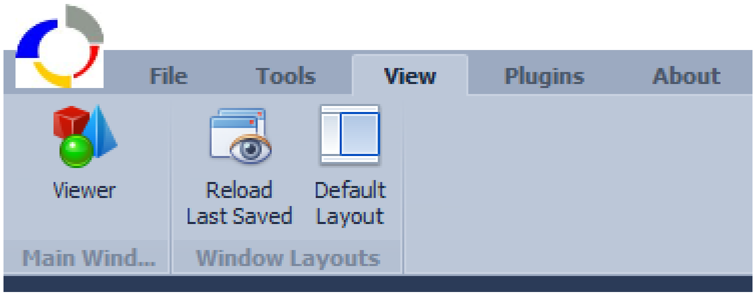

Figure 1-15. View menu of MSM.

Functionalities that can be performed from viewer menu are: project Explorer, reports, Viewer, Properties, and Model Explorer. Reload Last Saved and Default Layout. Five (5) major components of MSM can be accessed from the viewer sub menu. They are Project explorer, viewer, reports, properties, and model explorer.

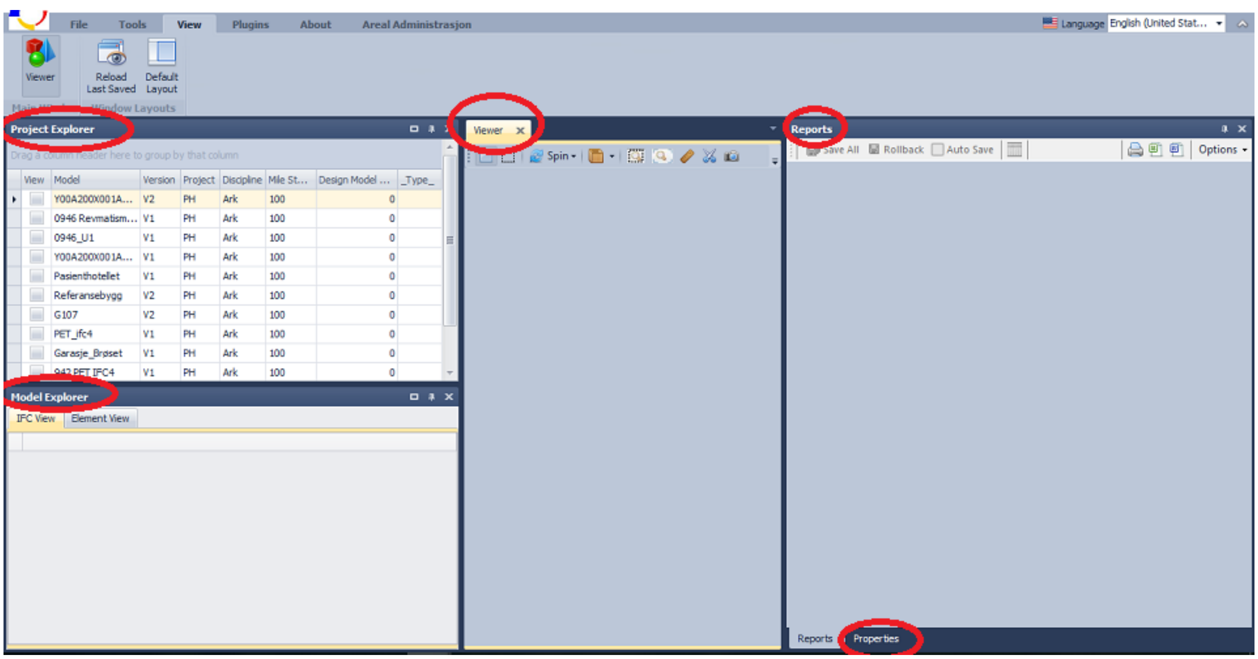

Figure 1-16. Viewer menu of MSM.

The project explorer interface automatically arranges all the models by project, however the grouping can be modified by using drag and drop functionality. The checkbox in view column allows the user to select which model to load into the MSM viewer. To open any desired model, users must select the model in the view column. Several models can be open at the same time. To close the model, users must uncheck the view column. Two models can be merged by opening both at the same time and 3D view of each will be merged 3D scene by the system. Users can select the original model during check in operation and imported data will be merged back in to the model by the system automatically.

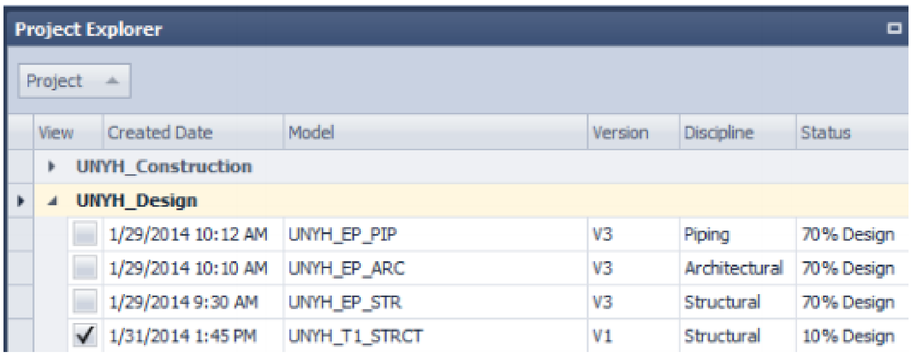

Figure 1-17. Project explorer menu of MSM.

Each element of the model is checked for existence or modification by performing a deep merge operation by the system. If the elements do not exist in the imported data, then it is erased from the model. The model elements are updated accordingly. A confirmation notification 'Merge finished successfully' will appear on the left bottom of the screen after the completion of merge process. Show messages button allow users to check whether the merge process is performed properly or not which provides output log of merge process and it can be investigated by the support team.

Functionality of model explorer is to organize the models which are loaded from project explorer based on IFC structure hierarchy. Each node in the hierarchy has a combine visibility check box that control the visibility of elements in MSM viewer. In MSM explorer visibility is checked on by default for all nodes. Models are presented in different tree structure in model explorer such as, IFC view: Site, building, floor, and elements of the floor. Element view: Covers, walls, doors, and windows, etc. TFM: Tree structure with elements tagged. Nomenclature: Main function, sub function, room name, space specification, capacity bearing. Catalog: Individuals type is listed through growing the anticipated type object. System: Grouping on model systems. By double clicking an element, user can expand the tree structure by zooming in and view the properties of the object listed in the properties section of the desired item. The assigned documents to the nodes in tree view will appear as icon outside the nodes. Single document icon shows that there is document for this node while multiple document icon represents there are also documents on underlying levels.

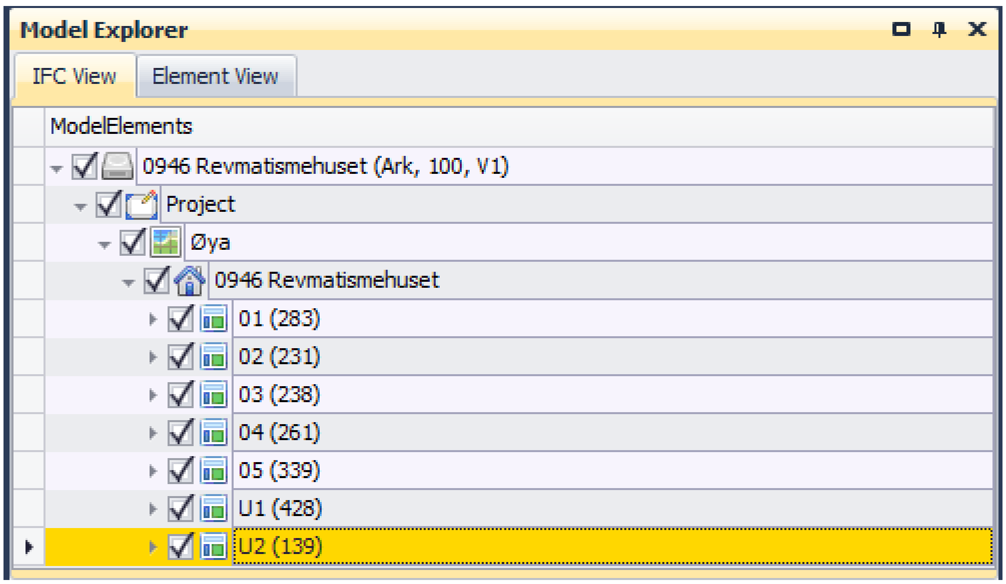

Figure 1-18. Model explorer user interface of MSM.

3D MSM Viewer is used to interact and view the models that are loaded from the project explorer in MSM viewer. Navigation in viewer can be performed in different ways but the most common navigation mode is spin mode. Any other mode can be selected by clicking on spin drop down menu.

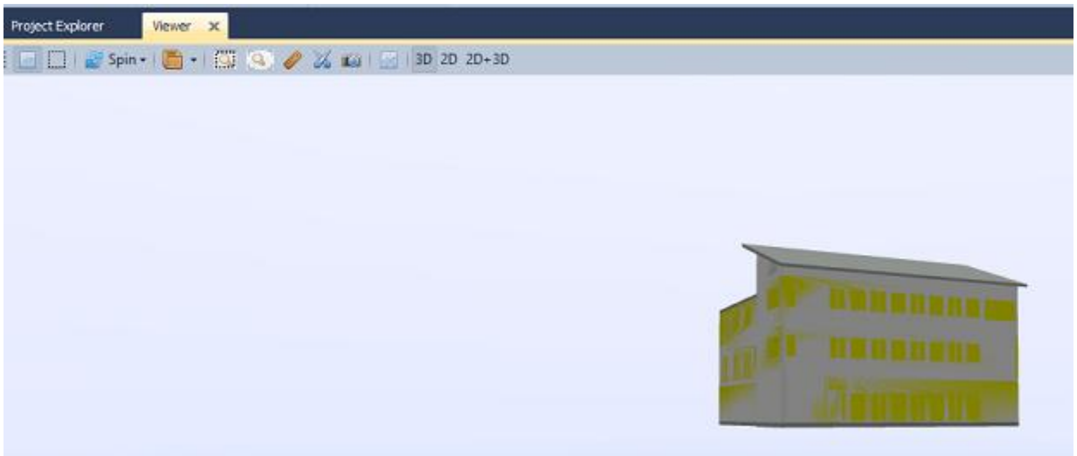

Figure 1-19. 3D viewer layout of MSM.

Reports window is a sortable and filterable view that reports results of the queries that a user run a selected project scope to the users. The report grid contains the information based on pre-built report query template created by users.

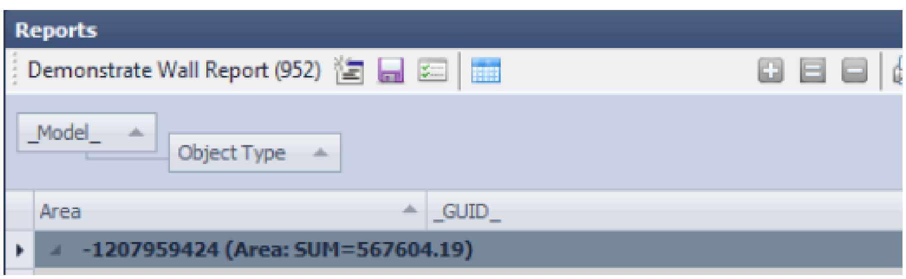

Figure 1-20. Reports window user interface of MSM.

Tool bar is the command center for the available functions in the MSM viewer. Users can use spin mode for spinning the model with mouse, walk mode is used to move around the model forward and backward using mouse. It is useful if users wish to navigate in one plan (e.g. on a floor), zoom mode is used to zoom in and zoom out the model, predefined views can be used by selecting view point mode. Predefined views are front, top, left, right, isometric, bottom, and back. Solid and transparent MSM viewer mode can be used to set the model for full rendered geometry or transparent icon can be used to toggle transparency settings for the selected objects, MSM viewer also provides screen shots functionality.

Figure 1-21. Viewer toolbar user interface of MSM.

The properties window of MSM allows users to have a descriptive information of property elements of a selected element. Properties of any item can be accessed by selecting the desired item and clicking on properties window. Properties on white window background are the properties of the selected item while properties on pink background are the properties inherited from the current object. In task tab all the task for the selected items are listed. In the relation tab all the relations of the objects are listed. Placement tab contains the details of objects relative coordinates and under documents tab all the documents related to the selected object is listed.

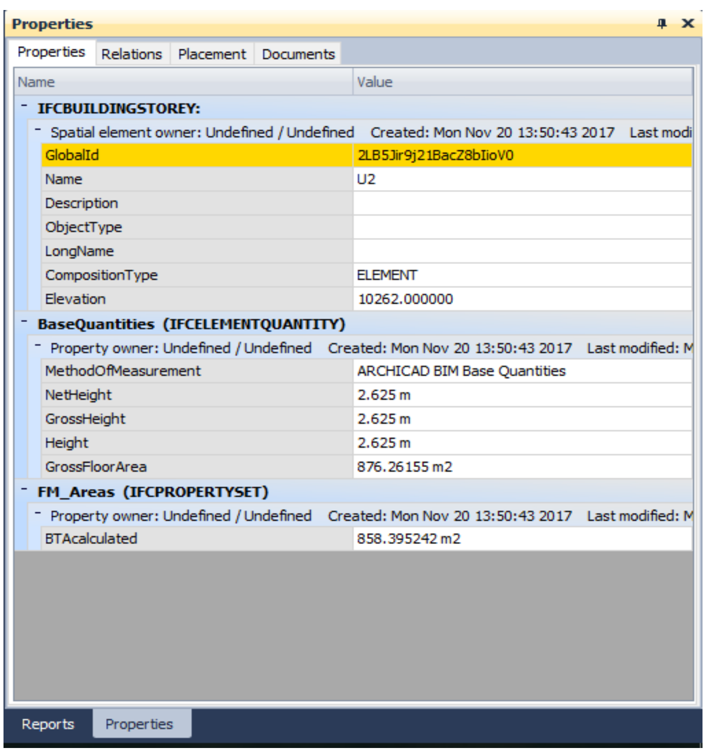

Figure 1-22. Properties window user interface of MSM.

Plugin tab consists of multiple plugins and grant access the users accordingly. MSM consist of plugins such as, VDC, BCF, and others. Moreover, it also provides areal administration plugin in separate tab. To check if a plug in is loaded, an installed client should be started and logged in with a client that have access to the attachment. If there is an extra tab of areal administration, it means that the plugin is successfully loaded.

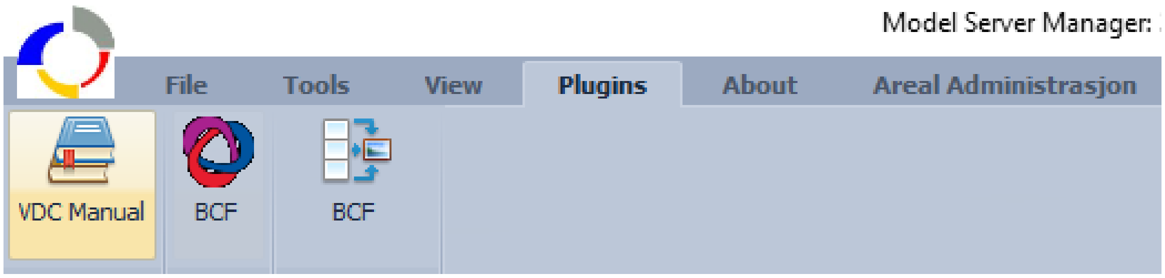

Figure 1-23. Plugin drop down menu user interface of MSM.

User can retrieve general information about the current version of MSM from about tab. It contains version information of MSM and user guide which consist of general user manual and steps to perform different tasks.

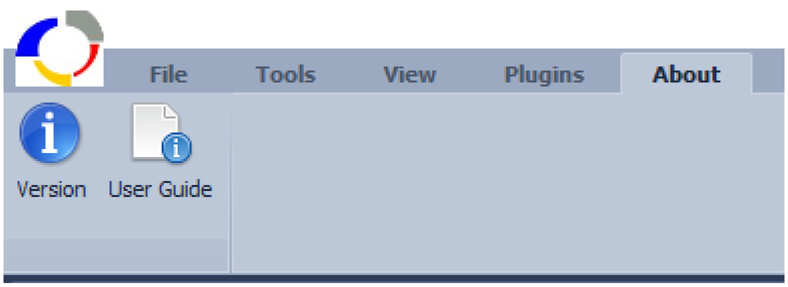

Figure 1-24. About menu user interface of MSM.

This study mainly focuses on UI and is intended to be a forerunner to further research and development of MSM. A focus of this research is to identify and highlight the areas that need improvements in the context of learnability and accessibility and to propose possible improvements that can be made to the elements related to the interface of the software. The concepts of learnability and accessibility are known by everyone related to product design and due to the broadness of learnability and accessibility, the research focuses on amassing a deeper understanding of learnability and accessibility and approaches to apply them in design[24].

The flow chart of the functionalities performed in MSM are below:

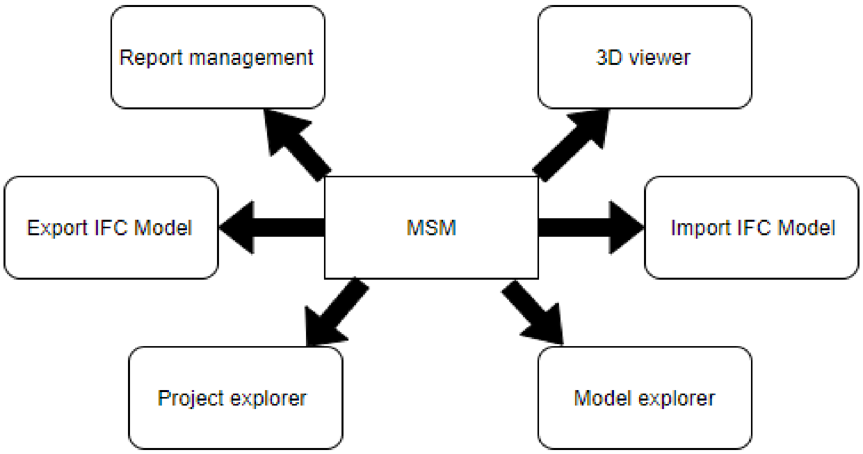

Figure 1-25. Flow chart of MSM.

An overview of actions that are performed by users of the system using MSM ribbon are presented in

Table 1-2. List of actions performed in MSM using ribbon.

Table 1-2. List of actions performed in MSM using ribbon.

Ribbon	**Tabs**
File	Login, Change Password, Import Model, Export Model, wide search and Narrow search.
Tools	Reports Management and Administration Center.
View	Project Explorer, Reports, Viewer, Properties, Model Explorer, Reload Last Saved and Default Layout.
Plugins	VDC Manuals, BCF, and Others.

[24]Express data manager details on jotne web site

About	User Guide and system version.

1.6 Research Questions

As pointed out earlier, this research is focused on MSM to identify the status of the learnability and accessibility of the UI and recommend improvements if necessary. Moreover, it attempted to offer recommendations that could be useful in the development of similar products. To that end, it attempted to answer the following questions:

- What are the learnability and accessibility related problems users face with MSM?
- Which learnability and accessibility guidelines were followed to design MSM?
- What can be done to improve learnability and accessibility of MSM and other related products in architecture and design?

2. Literature Review

This chapter review the previous, relevant, studies performed in the field of UD, accessibility, and learnability. Section 2.1 presents a brief explanation of the concepts and research performed related to UD and accessibility, followed by legislations and guidelines related to UD and accessibility. Further, the target groups and barriers of accessibility are discussed. Last, studies related to learnability and its barriers are discussed in detail.

2.1 Universal design and accessibility

The term UD was first mentioned by Ronald Mace, the founder of the center for UD at North Carolina state university (Scott at al. 2003). Researchers and students of University of North Carolina with a goal of making interior and exterior design easy-to use for persons with disabilities. To achieve this goal they proposed seven principles such as, "equitable use, Flexibility in use, Simple and intuitive use, Perceptible information, Tolerance of error, the design minimizes Low physical effort, size and space for approach and use"[25]. The goal of these principles is to make any interactive system easy to use, efficient, and satisfactory for everyone including persons with disabilities. The principles of UD can be applied to buildings, ICT technologies and other interactive systems[26].

In order to achieve UD, arguments were presented to merge different principles. Sachdeva et al, (2015) identified how systematic, social, and technical innovation is necessary to make technology economical and able to be agreed on. They also projected a framework related to designing sustainable information technology systems. It was based on the collection of their proposed design principles. They formed their design principles by merging sustainable design principles and UD principles, shown in Table 2-1. Intra-Discipline Characteristics (Stephanidis & Antona, 2013) and

Figure 2-1. Framework for designing sustainable IT system (Stephanidis & Antona, 2013)Burgstahler (2009) said that products and environments meet the needs of potential user

[25] https://www.uwyo.edu/wind/_files/docs/resources/ud_review.pdf
[26] https://projects.ncsu.edu/ncsu/design/cud/about_ud/udprinciplestext.htm

with a wide variety of characteristics if UD principles are applied. She mentioned "disability is just one of many characteristics that an individual might possess" (Burgstahler, 2009,p.1).

Nordli (2016) evaluated the Norwegian Broadcasting Corporation (NRK) from UD aspect. He mentioned that there are three levels of obstructions at NRK that prevents it from accomplishing a universally designed system; UD awareness barriers, organizational barriers, and technological barriers. He also recommended implementation of institutional change theory i.e. modifying values, standards, and practices that makes NRK an institution, so they can solve the existing problems in their organization. Moreover, Nordli (2016) claims that his research is applicable to other organizations as well.

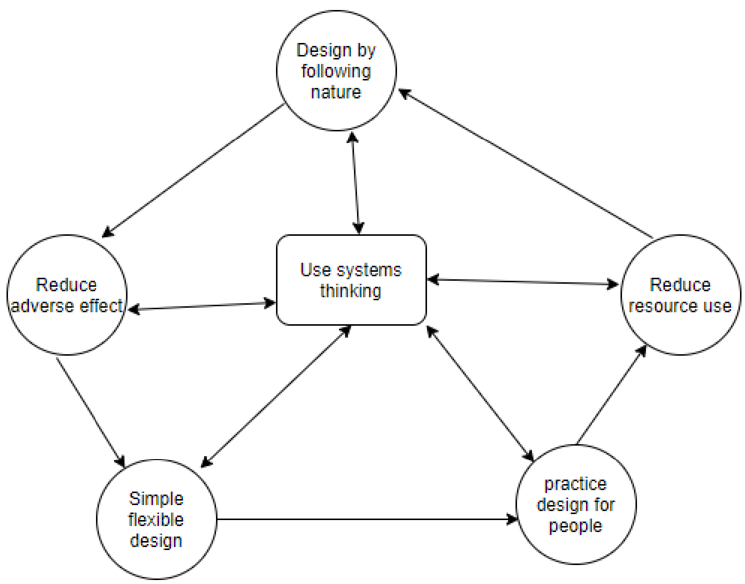

Figure 2-1. Framework for designing sustainable IT system (Stephanidis & Antona, 2013)

Table 2-1. Intra-Discipline Characteristics (Stephanidis & Antona, 2013)

Sustainability	Universal Design	Design principle properties
Reduce gap between natural system model and practice.	Equitability.	Doing design following nature as a mentor guideline.
Being conservative in using resources.	Error tolerance.	Condense the use of resource in system design.
Expand towards diversity.	Approachability.	Design for majority of users.
Optimal use of local environment.	Flexibility and simplicity.	Simple and flexible system that is customizable.
Influence over time.	Reduced effort.	Reducing adverse effects over time and enabling easy alternation of design.
Systems thinking.	Transparency.	Understand synergies and emergent properties.

The term accessibility was first introduced by Hansen (1959) to study the interaction between land use and transportation newtork. The difference between UD and accessibility is that, UD focuses on everyone regardless of their diversity such as, nationality, age, languange, culture, and others. Whereas, accessibility mainly focuses on providing usable systems to persons with disabilties. According to Stephanidis & Savidis. (2001), accessible systems in information and communication community are those whose information is accessible by everyone using any system. First world countires like USA, Canada, Australia and EU nations have already put a lot of efforts to fill the information gap for disabled and elderly groups. Web Content Accessibility guidelines (WCAG) [27]and Authoring Tools Accessibility Guidelines (ATAG)[28] are examples of their efforts.

[27] https://en.wikipedia.org/wiki/Web_Content_Accessibility_Guidelines
[28] https://www.w3.org/WAI/standards-guidelines/atag/

Additionally, section 508 of the US Rehabilitation Act[29] Amendments of 1998 sets standards. It requires all the information technology purchased or developed by federal departments to be accessible to persons with disabilities. Nielsen & Molich, (1990a) stated that, it is possible to evaluate usability of a UI using analysis method, computerized procedure, user testing and heuristic evaluation. For their evaluation process they preferred heuristic evaluation. They created nine heuristics (now referred as Nielsen's ten usability heuristics) and performed four experiments to evaluate user interfaces. They identified issues related to consistency, navigation, and user guide. It might be considered as a major step towards usability improvement of UI's.

Poore-Pariseau (2010) argued that training related to accessibility should be obligatory in organization for all professionals involved in development of content. Professionals must be familiar with accessibility guidelines and standards so that they can develop more accessible systems. However, a survey conducted by user experience (UX) and Human Computer Interaction professionals (HCI) indicated that professionals have knowledge related to accessibility but they are unable to utilize it due to some organizational factors (Putnam et al. 2012). Moreover, it has become a well-established fact that websites and software's require to be designed understandable and accessible.

Billi et al. (2010) proposed two steps methodology for accessibility and usability evaluation of mobile applications UI. First, they suggested to evaluate accessibility of the system because it will identify the issues relating to accessibility and modifications can be made before it goes to usability evaluation. Once, accessibility problems are identified and fixed, usability evaluation can be performed by dividing problems and solving them separately (Billi et al., 2010).

In two steps methodology of Billi et al. (2010), evaluation of accessibility and usability were performed by using different approaches. Selected users performed an evaluation combined with an expert by following the web accessibility initiative guidelines. Usually (3-5) users can

[29] https://www.section508.gov/content/learn/laws-and-policies

discover most of accessibility problems (Billi et al., 2010). Different guidelines from (WCAG 1.0) and (WCAG 2.0) were followed during their research mostly related to mobile application accessibility. Some of them are text alternatives should be provided to non-text content, layout and text content must be adoptable, user should be able to access all content, users should be allowed to control time limits and make sure documents are clear and simple.

An experiment was conducted by Billi et al. (2010) applying two step methodology to the interfaces designed by MAIS designer. Users with visual impairment and blindness were considered for the experiment, operating different devices. They identified more than thirty problems during the evaluation of the system. Major problems identified in their study were navigation and orientation problems faced by participants, Alternative text were missing in some places, users are not allowed to set their font type, incorrect entries are permitted, and some features are not completely clear. Accessibility barriers were identified as the major problems during user and system interaction.

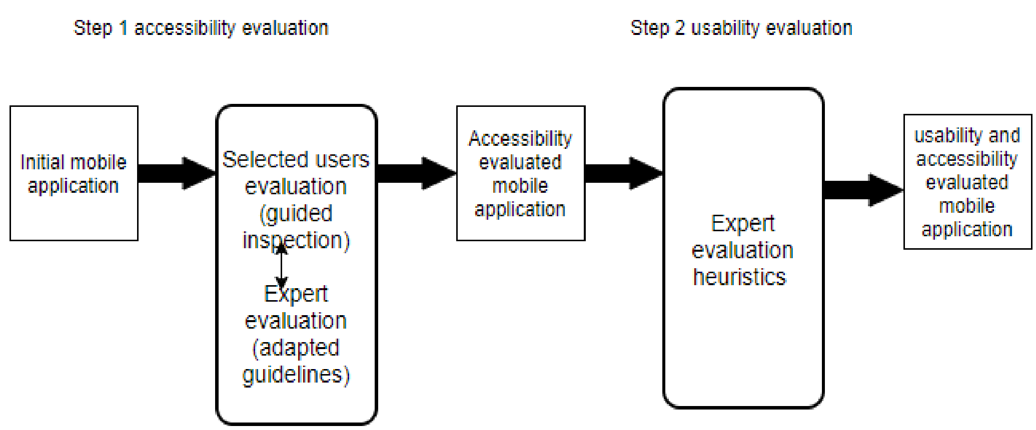

Figure 2-2. Two steps Methodology of evaluating accessibility (Billi et al., 2010).

Yamaguchi et al (2008) developed a software named Infty software through their organization science accessibility net. Infty reader can treat those scientific printed documents which was a problem for most of the optical character recognition (OCR) technologies. It helps to improve information interfaces for persons with visual disabilities. Infty can be converted to many accessible formats while this organization already worked on a math document editor “ChattyInfty”. It provides a facility to visually impaired persons to read math documents and author them with speech output providing a feature to convert documents to braille math code.

Persons with visual impairments can access ChattyInfty. To evaluate its accessibility, they had different experiments before launching it by comparing it with accessibility guidelines whether it full fills its requirements or not. This Organization claims that Infty is an accessible system because it fulfills all the guidelines of WCAG 2.0. The identified issue in this system is that it is hard for users to author or to write math expressions.

Aizpurua et al (2014) mentioned that user testing may not be an accurate methodology to evaluate accessibility of a system. They argue that it is possible to have difference in opinion between user and evaluator which can affect the evaluation results. It is suggested that evaluators and users should have a conversation/dialog as a user involving evaluation method. They also mentioned that it is better to involve user by navigating through web pages freely to identify complications in the system rather than giving them tasks which can stress them. Study conducted by Santana et al. (2013) pointed that it is easier for dyslectics to use web content with mono spaced, sans-serif fonts, not using too large text without line breaks, adding boxes, boarders, background, and white space, not using italic fonts, not using too small fonts, highlighting links, avoiding pure white backgrounds and justification.

Burgstahler et al. (2004) conducted a study to evaluate accessibility of windows XP. Microsoft supported this study with a purpose to determine the ease with which persons with visually impairment, elderly disabilities and mobility impairment used the accessibility features of windows XP. Tasks were located at the laboratory for usability testing and evaluation (LUTE) at university of Washington. Visually impaired and participants with mobility impairment took longer than the elderly participants. They outlined more than sixty (60) significant problems in windows XP usability. Some of them are; users were not aware of the presence of accessibility features, after finding the accessibility feature it was difficult for the users to use it. The lack of information provided by the system. Sometimes, it was difficult to locate the feature due to high contrast or other barriers encountered by visually impaired persons. Not allowing users to access information and features. For example, Narrator skipped over options on the screen, leaving blind users without sufficient information to complete tasks and others.

However, accessibility evaluation of new products is infrequently performed and, when they are, they usually take place after standard usability evaluation process is complete. If accessibility evaluation was possible to conduct throughout the design process, the availability ratio of better accessible systems to persons with disabilities would have been more than what it is now. Current accessibility evaluation practices often provide products with better accessibility features. This method normally provides a product that fulfil the minimum accessibility standards, but it does not mean that the system is easy to use, learn, or provide sufficient performance. "It's easier to find poor designs and good designs after the fact and it's even easier to write guidelines about what people should be doing" (Pernice & Nielsen, 2001, p.43).

Researchers have demonstrated a diversity of ICT systems evaluation. UD and accessibility both are now in more focus than ever because it is need of time not only persons with disabilities needs it but people with no disability or impairment also requires accessible ICT systems. The legislations and guidelines proposed by organizations for UD and accessibility are discussed in sub sections.

2.1.1 Legislations and guidelines

CRPD[30] principles states that, "respect for inherent dignity should be preserve. Non-discrimination. Full and effective participation and inclusion in society. Respect for difference and acceptance of persons with disabilities as part of human diversity and humanity. Equality of

[30] https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/article-3-general-principles.html

opportunity, accessibility, equality between men and women. Respect for the evolving capacities of children with disabilities and respect for the right of children with disabilities to preserve their identities".

CRPD[31] is a major initiative towards accessible systems. It was presented on 16th December 2006 at the United Nations Headquarter, New York. It was opened for signatories on 30th March 2007. Total eighty-two (82) signatories take part in the process. Forty-four (44) signatories to the optional and 1 ratification of the convention was made. It holds the record of highest number of signatories in the history of United Nation convention for any treaty on its foundational day and the fastest negotiated human rights treaty. Moreover, it is the first human rights convention to be open for signature by regional organizations. The convention became acting on 3 May 2008. It takes decade of hard work by the UN convention to reach to the point to minimize the gap between persons with disabilities and systems. A path which can identify the rights of persons with disabilities and a way to reinforce it.

United Nations (UN)[32] has declared Norway as a progressive E-Government country. Civil rights services are being linked to information and communication technology, such as voting during elections. Therefore, it is necessary that no one is being discriminated, including persons with disabilities. International telecommunication union (ITU)[33] acknowledge the need of UD by implementing laws for the empowerment of around one billion persons with disabilities (ICT Accessibility Policy Report, 2014). The Norwegian government is planning to make Norway universally designed by 2025 and to achieve this ambitious goal, a Disability Anti-Discrimination Act is already in effect since 2008. It states that 'all the ICT systems targeted to the public should be universally designed'. It is applied in all areas of society except family life and personal relations. The purpose of this Act is to ensure equality, equal opportunities, and

[31] https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html
[32] https://publicadministration.un.org/egovkb/en-us/reports/un-e-government-survey-2014
[33] https://www.itu.int/en/pages/default.aspx

prevent discrimination based on ethnicity, skin color, and religion. (Norwegian Ministry of Children and Equality, 2013).

In Norway, the anti- discrimination and accessibility act Diskriminerings- OG tilgjengelighetsloven is the Act[34] "to promote equality, ensuring equal opportunities and rights for social participation for all, irrespective of functional capacity, and prevent discrimination due to disability". It obliges public authorities to implement UD in their product or services. The act applies to ICT, built environment, transport, and education. Nordic guidelines mentioned four different categories of users who will benefit from this kind of support. People with physical impairments, sensory impairments, cognitive impairments, and Elderly people. (By 2020, 25% population will be aged 60 or above) disability occurs when exposed to different disabling environments [35].

First world countries are following web content accessibility guidelines (WCAG)[36], web accessibility initiative (WAI)[37], ergonomics of human-system interaction ISO 9241-171:2008[38], Nordic guidelines for computer accessibility[39], authoring tool accessibility guidelines (ATAG)[40], Nielsen usability heuristics[41] and others when they are referring to accessibility guidelines.

ISO 9241-171:2008 is responsible to provide guidelines for the interface of accessible system for use at home, work, In public or education sector. It deals with the problems related to designing accessible systems for persons with disabilities (physical, sensory, and cognitive abilities) and elderly people. It applies on the accessibility of interactive systems (web, learning support,

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[34] https://lovdata.no/pro/#document/NLO/lov/2008-06-20-42?searchResultContext=1131
[35] https://ec.europa.eu/eip/ageing/standards/ict-and-communication/accessibility-and-design-all/nordic-guidelines_en
[36] https://en.wikipedia.org/wiki/Web_Content_Accessibility_Guidelines
[37] https://www.w3.org/WAI/
[38] https://www.iso.org/standard/39080.html
[39] https://ec.europa.eu/eip/ageing/standards/ict-and-communication/accessibility-and-design-all/nordic-guidelines_en
[40] https://www.w3.org/WAI/intro/atag.php
[41] https://www.nngroup.com/articles/ten-usability-heuristics/

office, etc.)[42]. Section 508 of the Rehabilitation Act of 1973 amended in 1998, stated that, all federal departments are required to create their electronic and information technology (EIT) accessible to everyone including, persons with disabilities[43].

The software's used by authors (designers, web developers, etc.) to create websites and applications are referred to as authoring tools[44]. ATAG guide authors how to create accessible authoring tool for persons with disabilities. So, they can also create websites and applications. It facilitates authors with creating more accessible authoring tools with the help pf WCAG. To check authoring tools whether they are accessible or not ATAG guidelines can be approached for the evaluation process.

Another well-known standard is Web Accessibility Initiative (WAI), which is part of World Wide Web consortium (W3C). This organization is responsible for the development of web content accessibility guidelines WCAG 1.0 and 2.0. It provides all the guidelines on how to make web content accessible to everyone including persons with disabilities. In US, under the Americans with disabilities ACT of 1990, new public and private business construction generally must be accessible [45]. In Australia, the disability discrimination Act 1992 has numerous provisions for accessibility [46].

The Web Accessibility Initiative (WAI) produced the first version of the Web Content Accessibility Guidelines (WCAG 1.0) in 1999 [47]. After the production of WCAG 1.0, it is widely recognized that users with disabilities should be able to access all systems. Accepting the fact that WCAG 1.0 would become out dated, the World wide web consortium (W3C) formed a working group in 2000 to develop new guidelines named WCAG 2.0 as the second version of the W3C Web Content Accessibility Guidelines.

[42] https://www.iso.org/standard/39080.html
[43] https://www.section508.gov/content/learn/laws-and-policies
[44] https://www.w3.org/WAI/intro/atag.php
[45] https://www.eeoc.gov/eeoc/history/35th/1990s/ada.html
[46] https://www.humanrights.gov.au/our-work/disability-rights/about-disability-rights
[47] https://www.w3.org/TR/WCAG10/

From year 2000, unusual changes are seen in the Web. In the early days of web, it was only HTML but now it has changed into an exciting, and convincing medium for providing services on both static and mobile devices. Describing the requirements of Web content accessibility in a neutral language was one of the major goals of WCAG 2.0 (Reid & Snow-Weaver, 2008).

Web Content Accessibility Guidelines (WCAG 2.0)[48] provides wide range of recommendations for ensuring better accessibility of the system. Following these recommendations can help to build a system which can be used by persons with blindness, low-vision, deafness, hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, photo sensitivities and combinations of these. Adding these guidelines can make a system more usable in general.

WCAG is separated into three levels of compliance A, AA, and AAA each level requires a strict set of conformance guidelines and creates different web accessibility features accordingly. Examples of accessibility feature includes: "Semantic web markup, (X)HTML validation from the W3C for the page's content, CSS validation from the W3C for the page's layout, Compliance with all guidelines from section 508 of the US Rehabilitation Act[49], a high contrast version of the site for individuals with low vision, and low contrast (yellow and blue) version of the site for individuals with dyslexia, alternative media for any multimedia used on the site (video, flash, audio, etc.), simple and consistent navigation, device independent "[50].

WCAG 2.0 provides a lot of technical information and set of rules to be followed by web designers, coders, and editors. Web accessibility – Code of practice has been introduced, initially in the UK to help site owners and product managers to understand the importance of accessibility51. Web accessibility testing is a subset of usability testing where the target users

[48] https://www.w3.org/TR/WCAG20/
[49] https://www.section508.gov/content/learn/laws-and-policies
[50] WC# accessibility standards
[51]WCAG 2.0

are disabled that affect how they use the web. Goal to achieve in both accessibility and usability is to determine how difficult it is for people to use a web site and with the help of findings providing recommendations than can help to improve upcoming designs and implementations.

Web accessibility is a goal, not a yes/no setting. It is a tie of human needs and technology. In the future may be these standards will be outdated. There will be a need of new standards and updated versions of software's with more accessibility. Sometimes, there are gaps between system and user for example if a kid wants to use a web site, but he is visually impaired and uses assistive technologies. So, accessibility guidelines and tools help bridge these experienced gaps. However, the accessibility of a system can be measured by the level of guidelines followed by the systems.

(Nielsen & Molich, 1990b) developed heuristics for heuristic evaluation in 1990. In 1994 Nielsen refined the heuristics based on a factor analysis of 249 usability problems to create a set of heuristics with determined explanatory power. Currently, ten usability heuristics by Nielsen 52 are well recognized principles for UI evaluation. Since they are broad rules of thumb and not exact usability guidelines they are called heuristics.

Ten usability heuristics for UI design are: visibility of system status, match between system and the real world, User control and freedom, consistency and standards, error prevention, recognition than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose, and recover from errors, help and documentation [53].

2.1.2 Digital divide

'Until 20th century digital divide was referred to those with and without telephone. After 1990's it began to be used for those with and without internet'[54]. Now globally this term is referred to the difference in access to ICT systems. Those Circumstances in which there is a difference in

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[52] https://www.nngroup.com/articles/ten-usability-heuristics/
[53] https://www.nngroup.com/articles/ten-usability-heuristics/
[54] https://whatis.techtarget.com/definition/digital-divide

access to or use of ICT devices is digital divide (Campbell et al, 2001). New ICT systems does not consider digital divide between poor and rich, highly educated and educated, or male and female (Gómez, Hunt, & Lamoureux; Madhusudan, C. 2002). However, several studies indicated that persons with disabilities often experience digital divide (Fox, 2011; disabled consumers report 2013). Warschauer (2004) argues that the concept of digital divide is unfounded and unclear, it depends on the person whether s/he wants to have an ICT system or not.

2.1.3 Accessibility barriers and solutions

According to Government of Ontario[55], there are five main barriers to accessibility. They are attitudinal barriers are related to perceptions or behavior assumption about someone. i.e. if someone with visual impairment cannot understand you or you are superior from them. Organizational or systematic barriers occurs due to policies, events or rules that stops an individual to participate completely in a situation i.e. requiring students to take all subjects whether they are relevant or not. Architectural or physical barriers are those which happens due to inaccessible building designs, such as stairs, doorways, rooms, and others. Information or communication barriers are those barriers due to which persons with disabilities cannot access to information i.e. Poorly organized document or inaccessible by screen reader. Technological barriers arise when a digital device fails to provide access to its users or does not support assistive technologies. i.e. An inaccessible learning management system for students[56].

The accessibility barriers in an average software or website are several. However, the world wide web consortium (W3C)[57] lists some common accessibility barriers: alternative text, equivalent alternative text should be added to images. Key board input, all functionalities of the web sites should be operable using key board, and transcripts or captions should be provided for audio, it makes information accessible.

[55] http://www.uottawa.ca/respect/sites/www.uottawa.ca.respect/files/accessibility-cou-understanding-barriers-2013-06.pdf
[56] http://www.accessiblecampus.ca/understanding-accessibility/what-are-the-barriers/
[57] https://www.w3.org/standards/webdesign/accessibility

According to World Bank Group[58], over 100 million people around the world suffers from some type of disability. Crow (2008) mentioned four types of disabilities which effect online learning. They are motor impairments (restricted movement or control of arms), visual impairments (partial sight, Blindness, and color blindness), hearing impairments (deafness or hearing loss), and cognitive impairments (cognitive language and learning, attention deficit disorder, dyslexia etc.).

Paciello (2000) identified that visual impairment is the most referred type of disability in the literature related to accessibility. It is since most of the software's and websites rely on graphical and written presentation of the content. It is crucial for products to be universally designed or support assistive technologies. Typically screen readers and screen magnifiers are used as an assistive technology by persons with visual impairment (Crow, 2008). A good navigation mechanism can help persons with visual impairment due to the fact that they mostly use screen readers as assistive technologies. It is crucial to provide decent navigation mechanism because screen readers can work more efficiently. According to World Health Organization (WHO[59]), almost 466 million people around the world suffers from hearing impairment, including 34 million children's.

According to section 508 of the US Rehabilitation Act[60], all electronically delivered media should provide real time text captioning for all audio, video, and multimedia presentations. Pascual et al. (2015) evaluated accessibility of two websites developed in WordPress. Participants of the evaluation process were persons with hearing impairment, they identified that participants felt annoyed when they encounter non-textual content without captioning and due to the reason, they refer to the websites as complex. Chung et al. (2013) suggested to simplify and provide graphic representation of text, to increase clarity among persons with hearing impairment. This method might be fruitful since, persons with hearing impairment are more attractive towards graphical presentation.

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[58] http://www.worldbank.org/en/topic/disability
[59] http://www.who.int/en/news-room/fact-sheets/detail/deafness-and-hearing-loss
[60] https://www.section508.gov/content/learn/laws-and-policies

Persons with motor impairments mostly encounter difficulties accessing computer keyboards and mice. Therefore, they most often depend on assistive technologies to interact with ICT systems. These assistive technologies are mouth-sticks, voice recognition, and others (Hudson, 2002). Pérez et al. (2014, p.4) suggested that "add hot area around a hyperlink", provide buttons with larger sizes, "provide navigation bars", and providing direct access to other pages can facilitate persons with motor impairments.

Persons with cognitive impairments encounter low memory, problem solving, and conceptualizing issues. It is also considered as autism, brain injury, cerebral palsy, epilepsy, and others. Bohman (2004) presented recommendations for making accessible web content to persons with cognitive impairments. It should be simple, consistent, focused, error tolerant, provide enough time to users to interact with the system, and user should be allowed to recover from error. Rello & Baeza-Yates. (2014) argues that, it is possible to make textual content easy to read and easy to understand by dyslectics through implementation of lexical simplification. i.e. improving the words presentation and providing synonyms of difficult words. They suggested that content developer should adopt lexical simplification strategies as well.

Crow (2006) highlighted some UD practices that can facilitate designers to improve accessibility of designs. He mentioned that unnecessary graphics and flashing of on screen objects should be removed. Easily navigable designs, distinguishable text, and providing enough time to use the system can improve the accessibility. The weakening of sensory, motor, and cognitive abilities makes it tougher for persons with disabilities to interact with UI's (Hawthorn, 2000) and to acquire new computer techniques (Wendy et al, 2009).

2.2 Learnability

The term learnability as a component of usability was introduced back in 1976 (Licklider, 1977). In 1980's, early usability research were performed to asses users learning within word processing tools (Carroll et al, 1985). Human computer interaction (HCI) researchers maintain the term learnability and it became popular as an aspect of usability in mid-90's (Nielsen, 1994b). In this section, research performed related to learnability evaluation is reviewed. However, focus of this research is not on reviewing specific evaluation methodology or system.

Leung et al, (2010) used three design approaches to lower barriers of learnability for elderly people using mobile applications. They claim that using similar icons or allowing users to select from alternative icons of their choice can reduce learnability issues. They identified that simple interfaces can also help people to interact with UI's more easily and efficiently. Michelsen et al, (1980) used MADAM system which is an information storage and retrieval system, It was designed mainly as research tool. They mentioned that using new commands, increase in complexity of commands, giving less time for thinking, content related to learnabiltiy, minimizing rate of error, less guidance from help commands can be used to find the progress of users relating to learnability.

"The learnability of a design is based on comprehensibility: if you can't understand it, you can't learn it" (Heim, 2008, p.12). He mentioned that comprehensibility effects learnability and learnability in return increase the comprehensibility of a design. Rieman (1993) used diary method to evaluate learnability. He used naturalistic learnability methodology in which he gave a diary to the participants and ask the participants to keep all records of all the learning related activities of one week. He also mentioned that it might be difficult for the participants to recall all the activities. So, the report might be incomplete, but diary study followed by interview can cover the missing activities. Key results of diary data showed that only one learning event take place after eight hours of computing for a user. Their study also identified that trying new things, reading user guide, and asking for help are the three preferred strategies by users for resolving a problem. In some scenarios they approach online help.

Elliott et al, 2002 brought participants into a lab and ask them to perform set of tasks. After performing tasks, they gave participants a questionnaire of 25 questions related to learnability. Similar method was implemented by Butler (1985) to evaluate learnability of a system. They also recorded the completion time of task to measure learnability. Lazar, Jones, & Shneiderman found that users lose up to 40% of their interest since they are frustrated with computers. The most common causes of these frustrations are missing file, hard to find, and features that are unusable by the users. Birdi & Zapf, (1997) identified that elderly people reacts depressingly to errors. It is better to design error messages with more motivation and emotion. Part of difficulty is that interface usage requires learning and to make it learnable, user friendly and easy to operate applications are required. To make a system learnable it is necessary to follow learnability standards, organizations must set and implement learnability legislations and guidelines for systems to improve user interfaces.

Kato (1986) asked the users to interact with a system without using any instructional manuals. An expert sits with the participant and solve questions if a participant cannot answer/solve during the use of system. It was used as an alternative of think-aloud protocol. Novice users of the system can take part in this experiment because it was mentioned that participants are not expected to have any prior knowledge of the system. Tutor was also instructed to not encourage the participant to ask any question. No information was given to the user except solution to the current problem. The results shown that even cursor positioning was difficult for some novice users, identification of individual problems is a major use of question-asking protocol. R. Mack & Robinson, (1992) mentioned that think-aloud method helps user to find and learn something new about the system. However, think-aloud was only used for usability evaluation. He argues that think-aloud must be used for the evaluation process of learnability and it assisted researchers to identify learnability issues.

Measuring learnability does not have set of rules or guidelines but such suggestions and ideas are well-motivated in both human computer interaction and software engineering. Rafique et al. (2012) evaluated two online radio web applications Douban and Xiami, they are online music recommendation services in china. They specify different matrices that makes them capable to measure different attributes.

A matrices database was created to take suitable matrices from it. Six main learnability attributes were also presented in their study depicted in Table 2-2. Learnability attributes model. (Rafique et al., 2012) They evaluated, the group interface understandability and the group visual issues by observing all the groups who were involved in the task. Results of evaluation using matrices were presented. The overall understandability percentage for Douban was 89.7% whereas, Xiami received 86.1% because of its low scores in textual contents which was 63.75% making it a textually crowded interface. Douban scored only 66.67 % in understandable/ clear animation because of the unsuitable size and effects used.

Rafique et al (2012) also performed a Questionnaire based evaluation. Four questions related to learnability characteristics, task match, and interface understandability were asked as an online survey. Rafique et al (2012) measured one learnability characteristic using two questions. Interface understandability of Douban was 4% better than Xiami. Their study pointed some learnability issues such as, low animation quality, page overloaded with text and others.

Table 2-2. Learnability attributes model. (Rafique et al., 2012)

Learnability attributes
1. Interface understandability.
2. Feedback suitability.
3. Predictability.
4. Task match.
5. System guidance appropriateness.
6. Operational momentum.

Davis & Wiedenbeck (1998) introduced another methodology in manner of summative learnability evaluation. Users were given time for training and during test task they were left on their own only with the system manuals. Users need to perform a task in given time and then evaluation to perform based on final product. Similar protocols were suggested by Franzke (1995) where the hints given to users were followed and measured.

Butler (1985) argues that, well-organized, dependable, and effective tools are required to measure learnability. He discussed formative and summative evaluation and mentioned that it is about learning the usability problems related to the system, in a hope to improve the interface. Summative evaluation is for usability evaluation of the overall system. It is possible to perform summative evaluation by comparing one system to another system or checking if it follows the guidelines. He claims that formative learnability methodology is one of the most common forms of usability testing. To evaluate initial learnability think-aloud protocols were used in the HCI field.

A survey of software learnability: matrices, methodologies and guidelines has been observed and conducted by Grossman et al (2009). In their research they proposed metrics related to learnability of system according to the definitions presented by Andersen et al, (2012); Davis & Wiedenbeck, (1998); Santos & Badre, (1995); & Holzinger, (2007). Grossman et al. (2009, p.651) splits learnability into two main categories, “Initial Learnability: Initial performance with the system and Extended Learnability: change in performance over time”. The first three dimensions identified by Grossman et al, (2009) were related to Nielsen (1994), categorization of user experience. They added the fourth dimension for the designers interested in subsequent learning. Furthermore, they transformed the previous definitions by using its various dimensions and illustrated full taxonomy in Figure 2-3. Full Taxonomy (Grossman et al., 2009)

Their survey revealed that several matrices for learnability are present, but they are not together but in different research papers from a long time. Grossman et al (2009) were also unable to find a single collection of learnability matrices. They identified seven categories of matrices, they are supposed to be used for quantifying learnability. To identify learnability issues Grossman et al, (2009) also approached the methodology used by R. L. Mack et al, (1983). They asked users to verbalize as they worked, this protocol takes place during training and for analysis they recorded all the responses from the users.

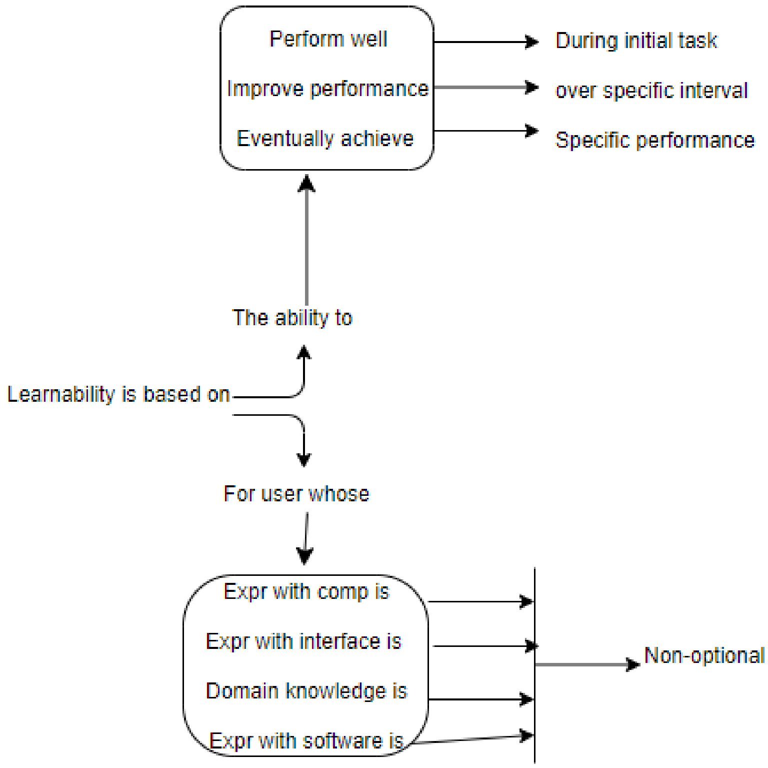

Figure 2-3. Full Taxonomy (Grossman et al., 2009)

According to Grossman et al (2009) for a software that depends on consumer early impressions, task matrices and capturing initial learnability can be used. For this experiment they used the popular computer-aided design system (AutoCAD). Participants were university architecture undergraduate students. Researchers thought it would be unsuitable to seek participants with no AutoCAD experience. However, in some situations participants have difficulties in learning to use a function of the system without verbalizing those difficulties. Those events were also recorded as learnability issues.

The problem arises was user's awareness of functionality that's the most common problem faced by users. They have tools, but they don't know how and when to use it. Other issue categorize by the researchers was that users can not locate the tools. They knew that the system is capable of this functionality, but they couldn't find it in the user interface, so they were not able to utilize it. Understanding functionality is other issue identified in their research.

Final problem categorize by the researchers was that users were aware of a specific tool or functionality, but they choose other and didn't use that tool.

Grossman et al (2009) suggested their categories to be set as guidelines for imrpoving interface learnability. They also mention that understanding task flow can be difficult for users while they are using complex interfaces. According to Grossman et al (2009) graphical user interface is a better way of making tools visible for the users. Howerever, their study show that user prefer transition over expert behavior. Five main principles effecting learnability specified in human computer interaction by Dix et al. (2004) are presented with definition in table 2-3.

Table 2-3. Principles effecting learnability (Dix et al, 2004).

Principle	**Definition**	**Related principles**
Predictability	Support for the user to determine the effect of future action based on past interaction history	Operation visibility
Synthesizability	Support for the user to assess the effect of past operations on the current state	Immediate/eventual honesty
Familiarity	The extent to which a user's knowledge and experience in other real-world or computer-based domains can be applied when interacting with a new system	Guessability, affordance
Generalizability	Support for the user to extend knowledge of specific interaction within and across applications to other similar situations	---
Consistency	Likeness in input–output behavior arising from similar situations or similar task objectives	---

In comparison with literature, it can be concluded that not a single methodology can be referred for learnability measurement. However, learnability of a system can be measured by its quickness that how quickly a new user can learn basic and advanced functionalities of a system considering their abilities. The overall discussion made so far about learnability and accessibility shows that the main aim is to make the systems easily usable and understandable to maximum people, including persons with different forms of disabilities.

2.2.1 Learnability barriers

Ko et al, (2004) defined learnability barrier as, if the belief of users towards a system is right before the beginning of learnability process, they will improve but if his/her believes are unacceptable, failures will probably be obvious. They identified six learnability barriers related to end user programming systems: design barriers are related to cognitive difficulties of a programming issue i.e. a situation where user don't know what s/he wants from the computer. Selection barriers are related to features of environmental functions i.e. a situation where user know what to do but doesn't know what to use.

Coordination barriers are related to the restrictions on programming interfaces i.e. a situation where users know what to do but they don't know how to make them work together. Use barriers are related to interface usability problems i.e. a situation where users know what to do with the computer application, but they don't know how to use it. Understanding barriers are related to the functionalities of a system i.e. a situation where users knew what to do but they didn't perform it up to their expectations. Information barriers are related to the attributes of an environment that make it difficult for users to access information i.e. a situation where users know the reason it didn't happen according to their expectations, but they don't know how to check it. Methods used in this study to evaluate learnability and accessibility of MSM are discussed in next chapter three.

3. Methodology

This research used a combination of heuristic evaluation and interviews to evaluate the learnability and accessibility of MSM. The product evaluated in this study is proprietary to Jotne. Therefore, it was required that the data collection process should be confined to Jotne and users of its products.

3.1 Selection of participants and data collection methods

An introductory meeting was held at Jotne before the start of this project. A brief introduction regarding Jotne and MSM was presented by their officials and notes were being taken during the meeting. After the meeting, the team responsible for the development of the MSM was contacted first to help with the heuristic evaluation of the system and second to help with recruitment of participants who can be contacted for data collections. During this study, it was possible to contact only seven of the participants which were later contacted via skype and email communications. Jotne required for all respondents to be selected from their own users first, due to business and intellectual property concerns and second, since it is reasonable to get feedbacks from the engineers who are using MSM. The results of the interviews were compared with the results of the heuristic evaluation to provide an overview on the accessibility and learnability of MSM.

3.1.1 Heuristic Evaluation

According to Nielsen & Molich. (1990. p,249), "Heuristic evaluation is done by looking at an interface and trying to come up with an opinion about what is good and bad about the interface". It is a method where experts judgmentally evaluate those features of UI that are related to usability. Heuristic evaluation was developed as a usability evaluation method for those experts who had some knowledge of usability principles but do not regard themselves as usability experts (Halstead-Nussloch ,1989).

Jeffries et al, (1991) compared four software evaluation techniques such as heuristic evaluation, software guidelines, cognitive walkthroughs, and usability testing. They claimed that heuristic evaluation was effective in finding the most serious problems with the least amount of effort. The benefit of heuristic evaluation for the evaluator is that it is the least expensive method and the fact that it doesn't require expensive tools or modern research labs (Jeffries et al., 1991). Heuristic evaluation alone can help to identify a wide range of usability problems without putting many resources and in limited amount of time. However, Matera, et al. (2002), said that heuristic evaluation is more subjective when compared with traditional user testing evaluation methods because it is dependent on evaluator's skills.

The set of heuristics to evaluate user interfaces can be different from system to system (Folmer & Bosch, 2004). Pinelle et al. (2008), for instance, developed heuristics to evaluate a video game design. They were similar to those ten heuristics developed by Nielsen[61]. However, the heuristics by Pinelle et al. (2008) were more related to problems related to computer games. They identified problems such as slow system response rate, limited freedom of customization, and lack of enough information to use it functionalities.

Nielsen (1994a) underlined that, heuristic evaluation may identify more major and less minor issues but still it has the capability to identify both. He also mentioned that sometimes it can identify those problems which are not identified by user testing but still both methods should be used to evaluate a system. A problem unidentified by heuristic evaluation can be identified by user testing and vice versa.

Heuristic evaluation was significant for this study because of its advantages. It provides some quick and relatively inexpensive way of collecting data designers could use to improve the design of MSM. In addition to the data, the heuristics themselves could be used by designers as guidelines to design accessible and learnable products. Every method comes with its own advantages and disadvantages. Therefore, it would be important to use heuristic evaluation together with other usability testing methodologies

[61] https://www.nngroup.com/articles/ten-usability-heuristics/

In literature there are several methodologies to evaluate software usability. However, there is little said about evaluating learnability specifically (Grossman et al., 2009). Therefore, in this research, a list of heuristics is developed for evaluating the learnability as well as accessibility of MSM using guidelines and heuristics proposed by other researchers. The learnability elements were taken from Nielsen usability heuristics, Microsoft[62] and the learnability attribute model of Rafique, et al. (2012). The accessibility elements for the heuristics were taken from Nielsen usability heuristics[63] and WCAG 2.0. The developed set of heuristics was used by a software developer in Jotne and the author for the heuristic evaluation of MSM. Table 3-1. Heuristics us, presents the heuristics with their sources.

Table 3-1. Heuristics used for heuristic evaluation.

Heuristics	Sources
1. Does MSM provide alternative text for images?	Perceivable (WCAG)
2. Does MSM provide visual presentation of text and images of at least ratio 4.5:1 except large text, logos, and those inactive user interface content?	Perceivable (WCAG).
3. Does MSM allow users to perform all functionalities with keyboard?	Operable (WCAG).
4. Supportive of Assistive technologies? i.e. screen magnifier, screen reader or voice recognition.	Robust (WCAG)
5. Does MSM allow users to resize text up to 200% without assistive technology?	Perceivable (WCAG).
6. Does MSM guide users to recognize, diagnose, and recover from errors?	Nielsen usability heuristics (NUH)[64]
7. Does MSM provide exactly the information and functionality that users' needs to accomplish their tasks.	NUH and Rafique et al. (2012)

[62] https://msdn.microsoft.com/en-us/library/windows/desktop/dn742443(v=vs.85).aspx
[63] https://www.nngroup.com/articles/ten-usability-heuristics/
[64] https://www.nngroup.com/articles/ten-usability-heuristics/

8. Info tips, does the icon Provides descriptive information?	Microsoft
9. Does the system provide enough documentation that can help new users to learn and perform all the functionalities of the system e.g. user guide or tutorial?	Learnability Attribute Model (Rafique et al., 2012)
10. Does MSM provide captions to non-textual content?	Perceivable(WCAG)
11. Does MSM provide ways to help users navigate, find content and determine where they are?	Operable (WCAG)

The above set of heuristics was developed believing that it is relevant for evaluating MSM. There might be criticism on the adequacy of the heuristic. However, it was able to identify some issues on the MSM. Moreover, there is always a possibility of improving heuristics with more details in other related further studies.

A meeting was set up with one of the developers of MSM. So, that he can evaluate the system with the above set of heuristics. The author conducted another heuristic evaluation by himself but left the items on 4.1.11 navigable to the developer. For that reason, it was important to garner the opinions of real users through the interviews conducted after this stage.

3.1.2 Interviews

As stated earlier, one method may not be enough to complete the evaluation process of a system. Therefore, it is important to have inputs from users of the system so that the research findings could be more credible. Therefore, users were selected for semi-structured interviews. Nielsen (1994) explained the interview method as, regardless of potential flaws, as one of the useful method in evaluative research. Interviewing is one of the suitable method to collect data to know user opinion (Bryman, 2016). Nielsen used the interview method to learn how using a website for a period of time builds user's impression of that site. Nielsen (1994) said that interviews are useful when one wants to explore user's general attitude or how they think about a problem after getting information. Several methods can be combined for the evaluation and data collection, which referred to as data triangulation method (Begley, 1996). This research also applied data triangulation by combining interviews with heuristic evaluation.

Kahn & Cannell (1957) described the interview method as, a discussion with a determination and they used it for collecting information related to a specific topic. Leonard (2003) pointed some drawbacks of face to face interviews such as, the cost and time associated with travelling for interviews from place to place and the possible impact of age, gender, facial expressions and appearance of both interviewer and interviewee on the interview process. Online interviews could resolve those drawbacks and they were the methods used in this research.

Online interviews are those 'conducted using computer supported communication' for the collection of data (Salmons. 2014, p.2). Interviews require planning of not only the questions to ask but also choosing whom to interview (Mason, 2017). Interviewees may find online interview less tense and more suitable because they can be interviewed at home or at work, in a familiar environment which would not affect their responses (Gruber et al., 2008).

Nielsen wrote a column in 2001 "first rule of usability? Don't listen to user"[65]. Nielsen's point of view was informed by his experience. He said that users would provide inaccurate feedback saying what they think the researcher would like to hear. He also said that users' memories fail them to remember all their problems with user interfaces. However, Nielsen said that using user opinions could be more valuable if they are collected after users started using a system and have a good understanding of how well it satisfies their needs.

The respondents of this study are users who have already been using MSM. Thus, one other good reason of choosing the interview method was the fact that the target group (users of the system) are well positioned to identify good and bad aspects of a system. User testing or task-based evaluation is not performed in this research due to the busy schedule of the users of

[65] https://www.nngroup.com/articles/first-rule-of-usability-dont-listen-to-users/

MSM and the geographical distance involved. Five of them were from the Netherlands whereas two of them were from Norway. However, all the questions asked in the online interview were related to the tasks they usually perform.

The semi-structured interview guides were mainly informed by the set of heuristics developed for the first part of the study. The main points of the interview schedule,

- How easy it is to use MSM?
- How informative is MSM with feedbacks as users perform their tasks?
- Accessibility features of MSM.
- What changes they want to see in MSM?

The average duration of the online interviews were around 20 minutes, varying from approximately 18-25 minutes. One online interview was interrupted due to some communication problems and it was conducted on the next day. All the interviews took place during the office time mostly around 13:00 in the afternoon. It could be possible that the office environment might have affected the duration of interviews.

3.1.3 Ethical consideration

Audio recordings were made, and notes were taken during the interviews with the interviewees' verbal consent. Users' identities are kept private during collection and analysis of the study. The respondents were informed about the procedure and assurance was given that audio recording will be discarded after analysis. However, privacy is still considered important and all audio recordings were stored on a separate offline medium. Furthermore, when audio recordings were transcribed any personally identifiable and sensitive information was left out.

3.2 Method of data analysis

Huberman & Miles (2002, p.309) explained that qualitative data analysis is "essentially about detection, and the tasks of defining, categorizing, theorizing, explaining, and mapping are fundamental to the analyst's role". In this study, thematic data analysis method is used to analyze the collected data. Thematic analysis is a common qualitative data analysis method that identifies themes within the data. It is a flexible method that provides autonomy to the researcher to include, discard, and interpret data according to their choice.

Harwood & Gary (2003) explained that thematic analysis was first used to analyze magazines, articles, and political speeches in the 19th century. Currently, it is used in several fields such as, physiology, sociology, journalism and other fields (Neuendorf, 2002). The main purpose of thematic analysis is to gain a complete knowledge of the phenomena. The findings of the analysis are categorized that may be used to create a model, theoretical map or categories (ELO & KYNGA¨S, 2008).

Denzin & Lincoln, (2011) and Silverman (2014) also used qualitative research methods in their studies. The six steps use to conduct thematic analysis are: drilling data, creating initial codes, themes are searched, themes are reviewed, defining themes, and creating the report[66]. However, Lazar et al (2017) identified one drawback of this method of data analysis, the results are made individually from the understandings of the researcher that may create biased/unfair results.

3.2.1 Coding Data

In this study, interview data transcription was used to draw out the responses from the interview participants. Coding eases to arrange interview data and direct us to present the explanations of it as one qualitative method (Oun & Bach, 2014). Important data from audio recording during the interviews were coded and grouped in the same manner as interviews.

3.2.2 Summarizing coded data

Recursive abstraction method is used to break coded data into smaller parts. This process is performed to remove unnecessary data and make the information easy to analyze. “By comparing the data using themes and codes, it becomes possible to identify patterns with in the data that otherwise are not apparent” (Polkinghorne & Arnold, 2014, p.1). One of the problem

[66] https://jvrafricagroup.co.za/six-simple-steps-to-conduct-a-thematic-analysis/

that many researchers mentioned in recursive abstraction is that, during summarizing data, it is possible to conclude data poorly, or in a way that is completely different from interviewee point of view. In this research, coded data and summary are reviewed more than one time to maintain the same meaning of the data as intended by the interviewees. During a sequence of steps performed to analyze data, a matrix containing interview guide and recognized themes by the researcher was used to position the codes. Table 3-2 provides an example from this matrix.

Table 3-2. Selection from the matrix with coded themes and interview responses.

	Interviewees response	
Themes	**A**	**B**
Navigation	• Simplify interface. • Accessibility button.	• Improve navigation.
User support	• Add tutorials.	• Improve user Manual.

After coding data and organizing data around themes, these themes are grouped into categories. The categories were created in understanding to what were the main motive for the rise and propagation of the concept. The results are presented in the next chapter.

4. Results

This chapter presents the findings from data collection and analysis methods used in this study. First, the results of heuristic evaluation performed by the developer of MSM and author are presented. Second, the results of online interviews conducted from the users of MSM followed by duration and ethical considerations applied during the interviews are explained. Last, the results of heuristic evaluations and interviews are summarized.

4.1 Results from heuristic evaluations

As mentioned, all the related guidelines from Nielsen usability heuristics (NUH), WCAG 2.0, Microsoft, and learnability attribute model (LAM) by Rafique et al, (2012) are compared with MSM in this study to perform heuristic evaluation. However, all functionalities of MSM are not evaluated by the author since he doesn't have the complete knowledge of those functionalities and no training were provided by Jotne to learn them. The results of heuristic evaluations performed by author and developer of MSM are discussed in subsections with the help of pictures.

4.1.1 Alternative text

Guideline 1.1 of WCAG 2.0 requires text alternatives for images and graphs. It is identified by both evaluators that in MSM, no text alternatives are used for images such as, images used in user guide and graphs used to represent models.

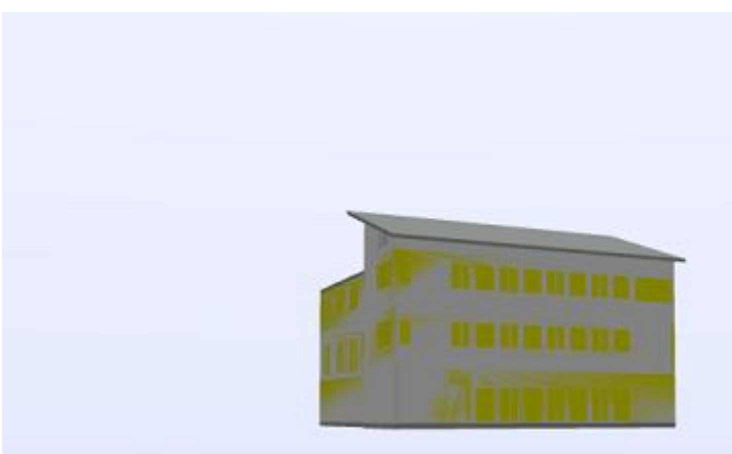

Figure. 4-1. No text alternative example

4.1.2 Contrast

Guideline 1.4[67] of WCAG 2.0 require color contrast ratio of at least **4.5**:1 except for large text, incidental, and logotype. First, the developer of MSM believe that, it follows standard color contrast requirement. He said that during the development of MSM accessibility guidelines were not followed. Therefore, it is possible that some pages of MSM might not fulfill the color contrast requirement of WCAG. To evaluate whether MSM is compliance with ratio **4.5**:1 or not, the color contrast of MSM's main menu and viewer ribbon was compared to the ratio **4.5**:1 by the author. The color contrast used in MSM is compliance with ratio **4.5**:1. However, it fails WCAG AAA for normal text as shown in Figure 4-2. MSM color contrast evaluation Moreover, MSM does not do well in terms of in high contrast as shown in Figure 4-3. MSM example of failing in high color contrast. This finding suggests that this specific page of MSM fails WCAG guideline 1.4.3.

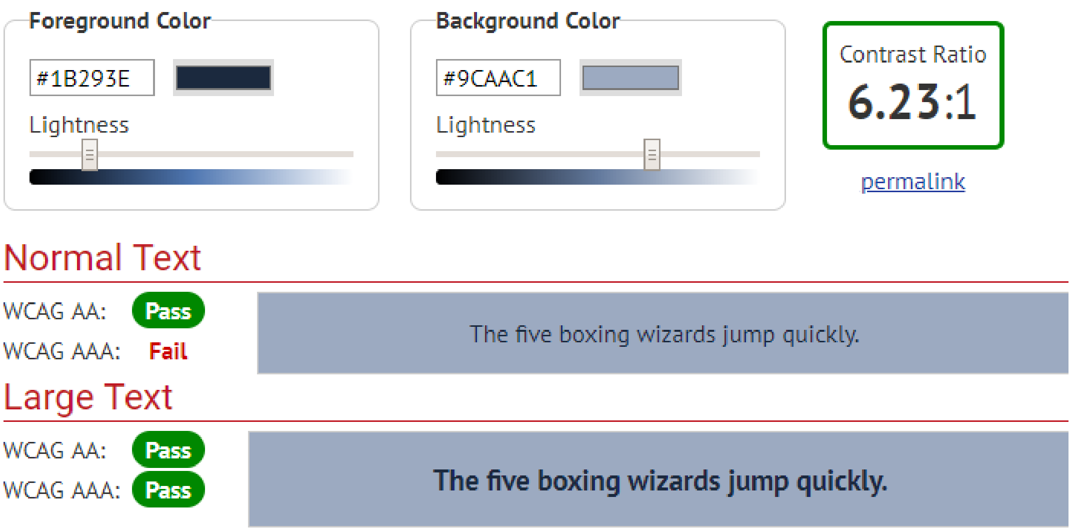

Figure 4-2. MSM color contrast evaluation

[67] https://www.w3.org/TR/UNDERSTANDING-WCAG20/visual-audio-contrast.html

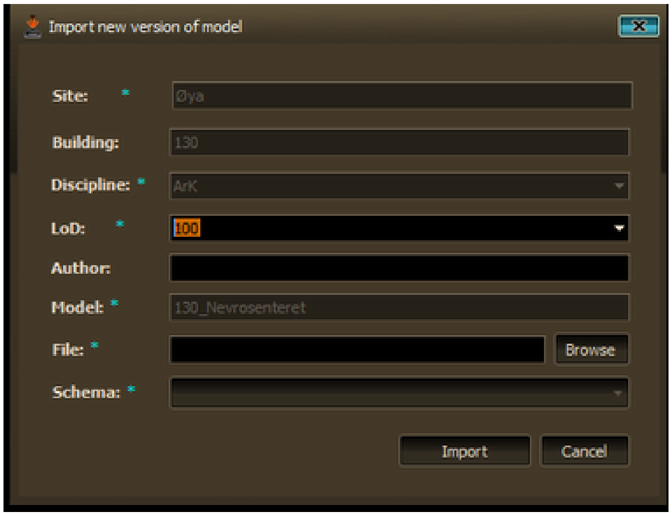

Figure 4-3. MSM example of failing in high color contrast.

4.1.3 keyboard access

Guideline 2.1[68] of WCAG 2.0 states that a system should allow its users to use all functionalities of the system through keyboard because there are users, including many older users with limited fine motor control, who cannot use a mouse[69]. Heuristic evaluations performed by author and developer of MSM identified that, MSM does not provide complete keyboard access to perform all its functionalities.

4.1.4 Assistive technologies support

Principle 4.1[70] of WCAG 2.0 requires web-based systems to ensure assistive technology support[71]. According to ADA section 508, assistive technologies are equipment's developed commercially, which is usually used to grow, sustain, or expand practical competences of persons with disabilities[72]. During heuristic evaluations, author used default windows voice recognition, screen reader and screen magnifier assistive technologies to evaluate whether MSM support assistive technologies or not. it was identified that MSM does not support voice recognition and screen reader assistive technology completely but it only support screen

[68] https://www.w3.org/TR/UNDERSTANDING-WCAG20/keyboard-operation.html
[69] https://www.w3.org/standards/webdesign/accessibility
[70] https://www.w3.org/TR/UNDERSTANDING-WCAG20/ensure-compat.html
[71] https://www.w3.org/TR/WCAG20/#ensure-compat
[72] https://www.section508.gov/

magnifier. However, the developer also mentioned during his heuristic evaluation that MSM does not support assistive technologies. By using assistive technology, a person who cannot use a keyboard or mouse due to some impairment will still be able to perform all the functionalities. i.e. if that person is using voice recognition it might be possible to perform most of the tasks. During the evaluation, MSM was lacking in this capability.

4.1.5 Resize text

According to WCAG 2.0. Guideline 1.4.4.[73], except captions and images text, all other text should be allowed to resize up to 200% without using assistive technology. During both heuristic evaluations it is identified that MSM does not provide that capability.

4.1.6 Error detection and diagnosis

According to Nielsen's usability heuristics, "Error messages should be presented in a plain language precisely indicated the problem, and constructively suggest a solution"[74]. The developer said that MSM provides error notification and possible recovery suggestions to the users. According to him, MSM informs the user immediately about the error and the user will not be able to proceed to the next step until the failed step is recovered. He said that, in some tasks the user can go back two or three steps to correct their errors, but it is not possible in all tasks. It depends on the nature of the task. MSM can identify the location of error by providing an error message, provides immediate feedback to the users except for some of the errors as the system is sometimes not capable to identify the errors. In that case, the developers of the MSM are approached to solve the problems. The system also informs the user whether the task is completed or failed with a message on screen.

However, the heuristic evaluation made by the author showed some difference from that of the developer. The author found that MSM provides error message but for some tasks, it does not provide hints on how to recover from the error. As shown in Figure 4-4. MSM not recommend

[73] https://www.w3.org/TR/2008/REC-WCAG20-20081211/#meaning
[74] https://www.nngroup.com/articles/ten-usability-heuristics/

possible solution of an error., the user has entered Incorrect data to import model but MSM provided only an error notification that import failed. It is identified that MSM does not recommend possible solution of an error for import model section.

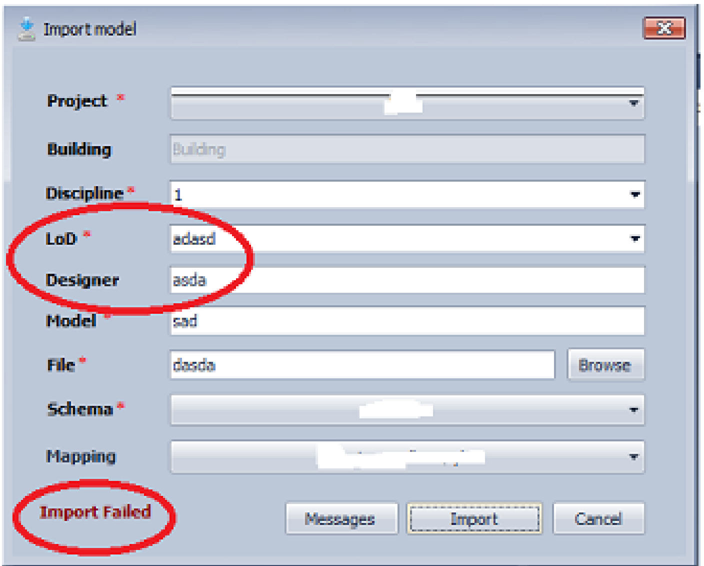

Figure 4-4. MSM not recommend possible solution of an error.

4.1.7 Simple design

In Nielsen's usability heuristics it is stated that, system should use minimalist design by removing unnecessary features from the system[75]. Rafique et al. (2012) mentioned that, software should provide required time to its users to perform functions or to complete his/her task. Results of both heuristic evaluations recognized that MSM might not be simple enough because all the basic and advanced functionalities are together (perhaps it may not be a desired attribute for MSM and other EDM suite products to have separate simplified and advanced views).

4.1.8 Info tips

Info tip provides a descriptive pop up message to the users when they point towards a labeled button/icon. Tool tip is a small pop up window occurrence when user points towards an

[75] https://www.nngroup.com/articles/ten-usability-heuristics/

unlabeled icon, it labels the unlabeled icons[76]. Developer of MSM mentioned that MSM provides info tips to its users. However, during heuristic evaluation by author it is identified that MSM only provides tool tips for labeled icons. It is not helpful for the users of MSM and it should provide info tips which can help users with descriptive messages. MSM fails to implement tool tips and info tips according to a definition by Microsoft[77] because tool tips are used for unlabeled icons but in MSM they are used for labeled icons. Difference between tool tips and info tips are presented in Figure 4-5. Tool tips example in MSM. and Figure 4-6. Info tips example (Microsoft word 2016)

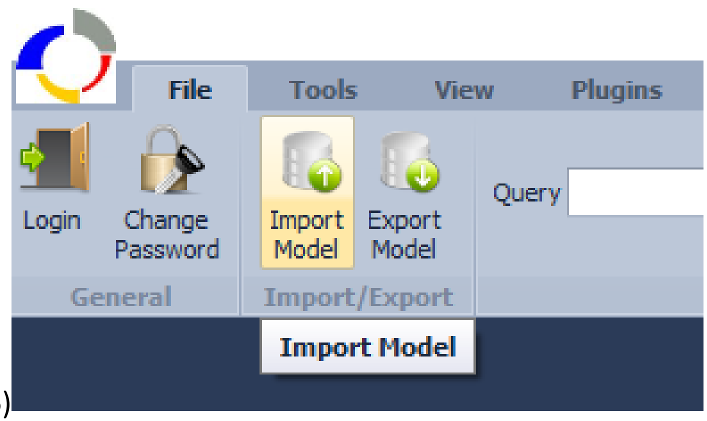

Figure 4-5. Tool tips example in MSM.

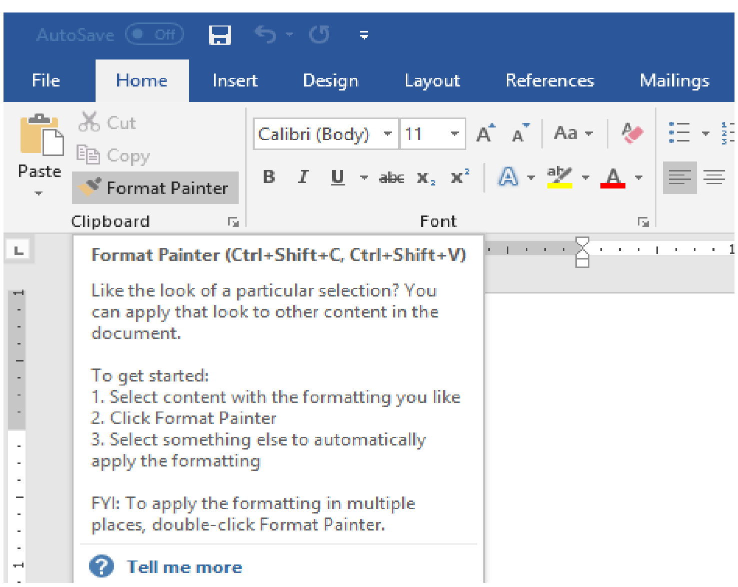

Figure 4-6. Info tips example (Microsoft word 2016)

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76 https://msdn.microsoft.com/en-us/library/windows/desktop/dn742443(v=vs.85).aspx
77 https://msdn.microsoft.com/en-us/library/windows/desktop/dn742443(v=vs.85).aspx

4.1.9 User guidance

To extent to which a system provides guidelines or assistance to the user could determine how well a user can perform his/her tasks (Rafique et al., 2012). In Nielsen's usability heuristics it is mentioned that, it might be essential to provide help documentation to the users. However, as the definition of learnability entails, it would be important to remember that it is better if a system is designed in such a way where a user can perform certain tasks without the help of documentations. The heuristic evaluations by the author and the developer of MSM identified that MSM includes a documentation where users can get guidelines for performing tasks. The documentation includes explanations with the help of images. However, video tutorials are missing which could have been preferable for some users who could have some disabilities.

4.1.10 Captions

WCAG 2.0 requires captions for all non-textual content including audio. It is identified during the heuristic evaluations that MSM does not provide captioning to any non-textual content. The developer said that captions feature is not added with MSM.

4.1.11 Navigation and progress update

According to Nielsen's usability heuristics, for error prevention, users should be presented a confirmation message before they commit an action. A guideline from WCAG 2.0 require ways to help users navigate, find content, and determine where the users are in the task. The author was not capable of comparing this heuristic with MSM due to the lack of knowledge. This heuristic is only done with MSM by the developer. The developer said that MSM provides progress update, keeps the user updated about his/her position in the task, and informs the users about the steps that are already performed by the users. MSM also notifies the user about the steps that are possible to take after certain action. It also provides a notification about the result of committing an action. However, MSM does not allow the users to know about the sub tasks that can be performed under a specific task because most of them does not have sub tasks.

4.2 Results of user interviews

The other method used to evaluate learnability and accessibility of MSM is online interviews. To conduct the interviews a list of questions (Table 8-1. User Interview questions.) were created according to the guidelines of WCAG 2.0, Nielsen, Microsoft, and Rafique et al. Interview results are divided into subsections and related questions were grouped together in sections such as, recognition and recovery from error, navigable, user support, appearance, user opinion and awareness.

4.2.1 Recognition of errors and recovery

The respondents were asked, in the event of errors, whether the system informs them about the location and nature of the error and whether it allows them to go back and fix it. All of them said MSM informs the user about the occurrence of error and it doesn’t allow them to proceed without correcting the error. However, they said that not every time it informs them about the nature of the error. As shown at section 4.1.6, the heuristic evaluation by the researcher confirmed that problem. As mentioned by a participant “there aren’t a ton of bugs in the system now, but user interface friendliness isn’t super”.

4.2.2 Navigation

In questions related to navigation, the respondents were asked, does MSM provide information about the location of user and completion or failure of the task. Whether it predicts the next possible task and allow users to redo or undo actions. Participants mentioned that MSM never provide sufficient information to the user about where they are in the task. Sometimes it is difficult for the users to identify in which specific step they are now. In some conditions, MSM provides notification about the success/failure of the task. As mentioned by a participant “MSM have a tool box, but its functionalities are not easy to understand". It does not allow its users to know what is going to happen next i.e. providing information to users before committing an action. Participants mentioned that it can save users from making too many errors and their time can be saved. They also mentioned that in some tasks MSM does not allow its users to redo or undo actions.

4.2.3 User support

The respondents were asked, in the event of user support, whether they received special training before using MSM or not. Do they solve issues by getting help from user guide of MSM or they consult the developers? Five participants mentioned that they receive very less help from the user guide. User guide is sometimes approached for basic functionalities and it is difficult to solve major issues using user guide. They claim that it is difficult to learn all the functionalities of MSM from user guide because it is a complex system.

A user pointed that, MSM should provide a button or option of "advanced and basic functionalities for the ease of users". The one button feature can help novice users to differentiate between major and minor functionalities of the system. Two interview participants said that we didn't receive any special training to learn the functionalities of MSM and it took a lot of their time to learn functionalities of MSM. Users of MSM try to resolve the issues by themselves using user guide or internet but sometimes it is difficult for them to resolve error then, developers of MSM are consulted for help. All participants mentioned that providing a step by step tutorials can help to solve this issue. The MSM already has included a user guide. However, the users don't regard it as a "step-by-step" video tutorial. In section 4.1.9 heuristic evaluations also identified problems regarding video tutorial and simple design.

4.2.4 Appearance

In questions that relates to the appearance of MSM, participants were asked, whether the icons used in MSM are understandable and their opinion about the colors used in MSM if they are user friendly and editable. Three participants mentioned that, most of the icons used in MSM are easy to understand and well positioned. One participant said that, icons used in MSM are not self-explanatory, and "it does not convey proper message to the users". However, its info tip feature is missing, and it does not provide complete description of the icons. The colors, font size used in MSM are user friendly and most of the users feel comfortable with them. It is also pointed out that MSM does not allow its users to change font size, font color, and background color according to the needs of users. As shown at section 4.1.5 and 4.1.8 heuristic evaluation by the author of this study also identified these problem.

4.2.5 User opinion

To provide user opinion and awareness about MSM users were asked, whether they wish to see any changes in MSM. In response, they said that MSM should focus on improving its user friendliness and usability issues. User guide should be updated by providing tutorials which can explain everything to everyone even the new users, it can save time and training cost. One participant claims that, “MSM is capable of quite of things, but it needs proper on time maintenance”. Interview participants had very little knowledge regarding UD, accessibility, and learnability. According to their knowledge UD is mostly related to persons with disabilities. The reason they associate UD with disabilities could be the fact that they are engineers and UD has become a well-known concept in architecture and facility design.

4.3 Summary

The overall results of heuristic evaluations and interviews shows that the MSM has qualities such as, feedback mechanisms, error reporting, self-explanatory icons. Which could help the user to quickly adapt to the system. However, there are areas that require improvement. For instance, the info tips can be fixed to be more descriptive, instead of telling the name of an icon. The help documentation could be designed with video tutorials to make it more effective

On the other side, there are important features missing which have to be considered for the next improvement of MSM. For instance, supporting assistive technologies, adding the possibility to enlarge text to 200% without AT, providing caption and alternative texts to some of the features on the interface could be considerations to be made for further improvements.

The results of heuristic evaluation and user interviews identified mostly similar issues in MSM. The common identified issues by both methods are presented in Table 4-1. However, for some issues it is quite difficult to differentiate whether it is an accessibility issue or learnability issue. Since, some accessibility guidelines are related/similar to learnability such as, sections 3.2 & 3.3

from WCAG 2.0. It states that web pages should appear in predictable ways and it should help users to avoid and correct mistakes. Recent literature related to learnability also suggests that for a learnable system it is required to be easy to learn. Help should be provided to users in finding content, learning the system and performing other tasks. So, in Table 4-1, issues are described according to their types, some issues are not clear whether they are accessibility issue or learnability issue. Therefore, they are described as accessibility/ learnability issues.

Table 4-1. Issues highlighted by heuristic evaluation and interviews.

Type	**Issues**
Accessibility	No alternative text for images.
Accessibility	No complete access to all functions using keyboard.
Accessibility	No access using voice recognition.
Accessibility	No complete access using screen reader.
Accessibility	No direct access to features (accessibility button).
Accessibility/learnability	Not efficient navigation.
Accessibility	Not more than one way to perform a task.
Accessibility	System does not allow users to change font color, size, or type.
Accessibility/learnability	Animation is not presented in at least one non-animated presentation mode.
Learnability	No info tips.
Learnability/accessibility	User guide consists vague, no tutorials.
Learnability/accessibility	No captions for non-textual content.
Learnability/accessibility	User awareness.

5. Discussion

Accessibility and learnability of a software are important qualities to make it quickly understandable by its users and at the same time to extend its usability to people who could have different types of disabilities. This research aimed to evaluate Jotne's MSM to see how the interface is accessible and learnable to its customers.

This study thus aimed to answer the following research questions:

- What are the learnability and accessibility related problems in MSM?
- Which learnability and accessibility guidelines are followed by MSM?
- What can be done to improve learnability and accessibility of MSM and other related products in architecture and design?

To answer these questions, two types of data collection methods were applied. The first was the heuristic evaluation method which utilized list of heuristics developed out of existing guidelines as well as recommendations from different studies. The researcher and one of the developers of the system performed heuristic evaluation on MSM. In addition to that online interviews and email correspondences were made with some of the users of the system. The findings were analyzed and interpreted through thematic analysis to answer the questions.

5.1 Identified problems in MSM

The data collected indicated that evaluators and interview participants agree on most of the identified learnability and accessibility problems. The problems identified in this research could be categorized broadly as awareness, learnability and accessibility. The purpose of this categorization is to explain the basis of the barriers, and to suggest a possible solution.

Awareness. This study suggests that the knowledge of MSM's users and developer towards universal design and learnability is at novice level, neither they are provided sufficient training. However, according to participants universal design and accessibility are more related to persons with disabilities and legal obligations. Further, this study identified that the awareness of users and developer related to accessibility guidelines and legislations are very little. These are the major reasons which results into awareness barrier and makes it difficult for the developer to recognize what, when, and where accessibility features should be considered. It is also suggested to provide learnability and accessibility awareness training to the users of the system.

Learnability. The learnability problems identified in MSM during this study are mostly similar to those issues proposed by Rafique et al. (2012). In their study, they used learnability attribute model, to compare two websites and determine which one of them is more learnable. Following are the similar learnability issues identified in MSM during study:

- Navigability feedback completeness: MSM Does not provide complete navigation feedback to its users as mentioned in the learnability attribute model system should provide accurate navigation.
- Predictive information suitability: MSM Does not inform users about the outcome of the task before committing the task.
- Help document appropriateness: MSM’s user guide does not cover all functionalities of the system. No video tutorial provided to its users. the users need for a step-by-step tutorial would suggest the need of adding video tutorials
- System warning appropriateness: The users are not warned before performing a task or committing a mistake.

Accessibility. In this research it is concluded that, MSM does not provide complete accessible system to its users. However, study conducted Burgstahler et al, (2004) identified similar accessibility issues in UI of Microsoft windows. They identified problems related to navigation, support of assistive technologies, and others. The identified problems in MSM during this study are:

- Does not allow all functionalities to be accessed from key-board.
- Does not provide ways to help users navigate, find content, and determine where they are.
- Does not help users avoid and correct mistakes.

- MSM is not completely compatible with assistive technologies such as, voice recognition, and screen reader.
- Not sufficient help is provided to understand the system.
- Caption availability: No captions are provided due to which disabled users may suffer.

In order to make an even more direct comparison, Nielsen[78] usability heuristics and WCAG 2.0[79] guidelines are approached. This research suggests that, MSM is not completely complaint with WCAG 2.0. Some functionalities of MSM evaluated during this research does not follow guidelines of WCAG 2.0. However, it is known that WCAG mainly focuses on web content, but still similar functionalities of software may also follow them. i.e. alternative text, keyboard access, and others. It can be concluded that MSM does not fulfill the requirement of CRPD[80] for Universally designed system.

In Nielsen's[81] usability heuristics, it is required that system should provide freedom to its users, because they often perform actions mistakenly and might need to redo the action or exit it[82]. MSM does not allow its users to undo or redo actions in some tasks and users must go through a dialogue after committing a mistake. MSM is a complex system and users might require regular help. However, the help documentation of MSM does not provide any tutorial to its users. Its user guide has vague and it need an update with the inclusion of video tutorials. In usability heuristics by Nielsen, system should provide complete information of its functionalities to its users.

[78] https://www.nngroup.com/articles/ten-usability-heuristics/
[79] https://www.w3.org/TR/WCAG20/
[80] https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/article-2-definitions.html
[81] https://www.nngroup.com/articles/ten-usability-heuristics/
[82] https://www.nngroup.com/articles/ten-usability-heuristics/

5.2 Learnability and accessibility guidelines followed by MSM

This study, in combination with previous research, identified that MSM is not completely compatible with basic learnability and accessibility standards such as: Nielsen usability heuristics, learnability attribute model, WCAG 2.0, and US access board section 508. Therefore, it shows that MSM do not completely follow learnability and accessibility guidelines, by not providing assistive technology support in the system, no shortcuts, and no complete key board access to its users.

The developer of MSM also mentioned that during the development of the system no learnability and accessibility guidelines were followed. Standard software development procedure was followed, and no testing related to learnability and accessibility was performed. The documentation of MSM does not provide any relevant information regarding learnability and accessibility support. It has no information of using the system for persons with disabilities.

5.3 What can be done to Improve MSM and other related systems?

The need of institutional policy to consider accessibility and learnability (or in general UD) during further improvements of MSM. Build on the heuristic set used in this paper or modify other available guidelines according to the nature of the software, to create accessible systems. Add accessibility button as part of the toolbox or add it in some other way. Users who have problems with color contrast or other accessibility issues can opt to use the tools to change the appearance of the interface to what they want. An example of accessibility button is shown in Figure. 5-1**.** Direct access to accessibility features (Inspira).

Moreover, it is important to follow all the usability guidelines, principles, legislations, and standards set by international organizations. First, before implementing a new design, testing must be performed on the old design and good features of the system should be kept. Second, system should be compared to other competitive designs and create new prototypes of new design and evaluate them. After evaluation of prototypes compare the best prototype with the usability (learnability and accessibility) guidelines and principles. Lastly, design must be tested at least once before implementation. It is necessary to include the users of MSM during the design phase of new versions, to know what is missing in the existing system.

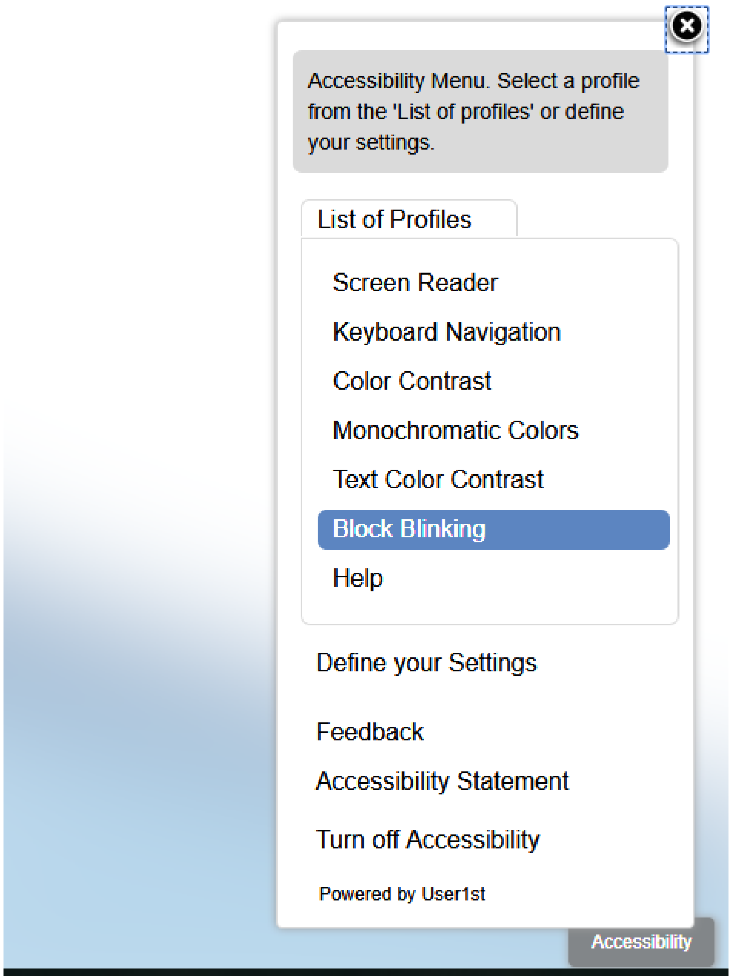

Figure. 5-1. Direct access to accessibility features (Inspira[83]).

[83] https://inspira.un.org/psp/PUNA1J/?cmd=login&languageCd=ENG&

6. Conclusion and future work

Importance of learnability, and accessibility in the field of ICT is presented in this research. It is identified that, MSM and other products can increase their userbase by following principles, guidelines, legislations, and standards set by organizations for learnable and accessible systems. This study uses MSM as a case study to gain information on the relationship between UI, learnability, and accessibility. Further, this research attempt to explain the reasons behind the occurrence of these barriers between users and MSM. Lastly, it is assessed how learnability and accessibility effect the system and its implementation can change user interaction with system.

This research had three main aims: to identify learnability and accessibility related problems in MSM. To investigate which learnability and accessibility guidelines were followed during the development of MSM. Lastly, how to improve learnability and accessibility of MSM and related products. All three research questions were answered during this study and recommendations are suggested for improvements of MSM.

During this study, data is collected from the users and developer of MSM through online interviews and heuristic evaluation. It helped to identify major issues that exists in MSM. The issues identified in this research were categorized as awareness, learnability and accessibility. This categorization is to explain inability of MSM to achieve learnability, accessibility and to provide possible solutions. The findings and recommendations of this research can be applied to other products. i.e. websites and software's.

Using the findings, this research provides authentic recommendations to MSM to become a learnable and accessible system. It is suggested that changes in organizational routines at Jotne should be considered. Users of MSM must be involved in the design phase of next version of MSM because user awareness is an important aspect which is identified during this research. Information related to learnability and accessibility must be conveyed to the developer's team and users. System and user interaction also depends upon the level of user awareness regarding an issue. Guidelines and legislations related to learnability and accessibility must be implemented to solve problems such as, navigation, user assistance, assistive technology support, and others. To accomplish completely accessible system in an organization it is important to provide sufficient awareness to the employees and the users about guidelines and legislations.

Other recommendation to be considered is the addition of image description in MSM, although first step can be the addition of alternative text by the developer to existing images or graphs. Second step might be providing a functionality to the users of MSM to include alternative text for images and graphs. It is necessary that users add sufficient information in text description to convey the meaning of the image to the readers with impairments. It is important to provide complete information in the text description because it can change the meaning of the image specially for assistive technology users.

This research identified that the color scheme for main menu comply with WCAG guideline 1.4.3. However, it provides insufficient output between foreground and background in high contrast settings. To achieve sufficient contrast to comply with WCAG guideline 1.4.3, the dark colors should be altered to colors that comply with WCAG guideline 1.4.3. WCAG guideline 2.1.1 require all systems to enable users with or without assistive technologies, to identify and use all functionalities of the system with keyboard. This study recognized that MSM does not provide access to all its functionalities using a keyboard. It is recommended to add this feature to benefit users with different forms of disabilities specially those who are unable to use mouse.

MSM does not support voice recognition and screen reader (narrator) efficiently. It is recommended that MSM should focus on providing sufficient support for assistive technologies because users including, persons with disabilities use these technologies to perform their tasks. This study also suggests that in some cases MSM provide insufficient information to the users when error is occurred as shown in Figure 4-4. MSM not recommend possible solution of an error. It is recommended that a simple error and recovery description should be provided to the users. It should support assistive technology such as, screen reader. So, that all users including persons with disabilities can also recover from an error situation easily.

It is recommended to provide training about all the functionalities of MSM. If training is not possible due to long distances and other issues, video tutorials with captions must be included in the user guide of MSM. Captions are necessary because persons with hearing impairments can encounter problems while learning from the tutorials and they can feel discriminated. Info tips for every icon must be descriptive. MSM provides tooltips for icons but they should be used for unlabeled icons. However, the icons used in MSM are labeled so, they should use info tips to convey complete information about an icon to a user.

As this study has identified a set of obstructive factors. In future work user testing could be considered to gather data related to more in depth functionalities of MSM. Further studies might help to discover those aspects of MSM related to learnability and accessibility that are not cleared during this study.

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8. Appendix A: User interview questions

Table 8-1. User Interview questions.

1.	Does the system identify the location of error?
2.	In case of error does the system inform you about the nature of the error?
3.	Does the system allow you to go back and correct the errors you made?
4.	Does the system tell you where you are in the task?
5.	Does the system provide any notification whether the task is completed or failed?
6.	Does the system predict about what is going to happen after certain task and does it allow users to redo or undo actions?
7.	Do you use the user guide to help you learn and perform tasks?
8.	Is it difficult to learn all functionalities of MSM from user guide?
9.	Did you get any special training to learn the system?
10.	In times where you want to immediate help/support as you work on your tasks, what would you do?
11.	Are the icons and labels of the software self-explanatory?
12.	Do you find software content (font size, font color) readable and understandable?
13.	Do you find the overall colors used in the software user friendly?
14.	Does the system allow the user to change font size, font color, and background color according to their needs?
15.	What improvements in MSM would you like to see in the future?
16.	Do you have knowledge about universal design, accessibility, and learnability?