Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering

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Smart use of IT for better artificial turf pitches - development of a visualisation tool for dissemination of sustainability research

Bachelor's thesis in Digital Business Development
Supervisor: Kirsti E. Berntsen
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Abstract

This report conveys how we developed a technical tool in the context of the Artificial Turf project (Kunstgress 2021 (KG2021)).
KG2021 is a project conducted by the Centre for sports facilities and technology (SIAT) at NTNU. The application is aimed for dissemination of the insight established by the project to -owners, procurers and decision-makers regarding artificial sport pitches and potentially contribute to more sustainable artificial pitches.

The artificial turf market will be described to establish a common understanding of the reason for developing the application. Change management and data-driven decision making will also be highlighted as relevant topics for our work. Our technical tool can be used, thus contributing to more sustainable sports pitches insofar as it fits with the users' context of work practices and areas of expertise.

Our methods are inspired by the Design Science Research methodology, and agile system development with continuous iterative development for establishing our design. During the development phases, meetings with our client contact were a frequent activity. The purpose being to concentrate first on the requirements specification and the application's overall design. After deciding the requirements, prototyping was the next task to complete before conducting the user tests. The user tests provided us with valuable and necessary feedback for completing our final solution.

The outcome of this bachelor's thesis is a fully accessible dashboard which visualises data for comparison based on a dataset of reports from 37 artificial pitches throughout all of Norway. The dashboard displays the different aspects in regard to both the economic and environmental costs of owning a pitch, notably the maintenance costs over a 10-year period. Making this dashboard for KG2021 could facilitate wider dissemination and better general knowledge on the complex topic of achieving sustainable artificial football pitches.

Sammendrag

Denne rapporten formidler hvordan vi utviklet et teknisk verktøy for kunstgressprosjektet (Kunstgress 2021 (KG2021)).
KG2021 er et prosjekt utført av Senter for idrettsanlegg og teknologi (SIAT) ved NTNU. Applikasjonen har som mål å formidle innsikten etablert av prosjektet til eiere, innkjøpere og beslutningstakere angående kunstgressbaner og potensielt bidra til mer bærekraftige kunstgressbaner.

Kunstgressmarkedet vil bli beskrevet for å etablere en felles forståelse av grunnlaget for å utvikle applikasjonen. Endringsledelse og datadrevet beslutningsledelse vil også bli belyst da dette er relevante fagtemaer for å belyse applikasjonens kontekst for bruk. Et teknisk verktøy må passe inn brukernes kontekster og fagbakgrunn dersom det skal bli anvendt og faktisk kunne bidra til endret praksis – her, som mer bærekraftige fotballbaner.

Våre forsknings- og utviklingsmetoder er inspirert av utviklingsvitenskap, Design Science Research- rammeverket, og basert på kontinuerlig iterasjon under utvikling. Under utviklingsfasene var møter med oppgavestilleren en hyppig aktivitet. Hensikten var å konsentrere seg om kravspesifikasjonen og løsningens overordnede utforming. Etter å ha bestemt kravene var prototyping neste oppgave å fullføre før brukertestene ble utført. Brukertestene ga oss viktige og nødvendige tilbakemeldinger for å videreutvikle vår endelige løsning.

Resultatet av denne bacheloroppgaven er et fullt tilgjengelig dashbord som visualiserer og sammenstiller data basert på et datasett fra 37 kunstgressbaner som er lokalisert rundt om i Norge. Dashbordet viser de ulike aspektene knyttet til både økonomiske og miljømessige kostnader ved å eie en bane, spesielt vedlikeholdskostnader over 10 år. Et slikt dashbord vil for KG2021 kunne være et nøkkelelement som muliggjør bredere formidling og mer generell kunnskap rundt det komplekse temaet som bærekraftige kunstgressbaner er.

Preface

This bachelor thesis is completed in collaboration with SIAT and the project of KG2021, under the Faculty of Information Technology and Electrical engineering (IE), at the Norwegian University of Science and Technology (NTNU), spring 2022.

We were delighted when we received this assignment, because we wanted to develop a product. The process has had its ups and downs, and the learning curve has been steep. Nevertheless, both of the students have developed personally, as challenges and obstacles that occurred were managed as a team.

A special appreciation will be given to our friends and family, who supported us along the way. We want to thank the contributors to the user tests, as this thesis would not be complete without their participation.

The last appreciation will be given to our supervisor, Kirsti E. Berntsen, and our client contact Bjørn Aas from KG2021.

Herman Berger Danielsen

Mathias Pedersen

18.05.2022, Trondheim

Task description

The client contact

Our client contact is represented by SIAT and KG2021's project leader Bjørn Aas.

The purpose of the task

SIAT is leading the project KG2021 - a project about the artificial turf surfaces of the future. The project follows six pilot courses several years to study different materials and usability. An important part of such a project is good lifetime economy, and such models are poorly developed for this sector. The purpose is to develop a model where a buyer as part of his evaluation of offers from suppliers can take out an LCC analysis for a proposed solution.

The LCC model is based on recognised theory and includes all input factors needed for purchase, management and operation during the lifetime of the facility. The application is based on an existing data set of 40-50 projects from the market, and on the basis of this be a tool where LCC can be simulated on the basis of a variation of input parameters such as price and quantity, estimated time consumption for maintenance and possible residual value of products after disposal.

Note: The description is copied from the task description and translated into English.

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1. Introduction

'KG2021 - et prosjekt om framtidens kunstgressbaner' ("Artificial sports turfs of the future"), is a four-year dissemination and research project led by the Centre for Sports facilities and technology (SIAT) at the Norwegian University of Science and Technology (NTNU). They collaborate with counties, municipalities, sports clubs, industrial actors and international researchers. SIAT is the project leader and part-owner, while the remaining ownership belongs to Akershus, Østfold, and Trøndelag county municipalities. The program started in 2018 and will end in 2022.

The background for the KG2021 project is that several reports over the last two years, from multiple European countries, describe various environmental problems related to the use of rubber granules in artificial turf pitches. They report that granules are being transported via waterways, and mixed into sediments, all the while leaking heavy metals to the surroundings over a long period of time. In particular, the problem stems from the use of synthetic infill, a product often based on discarded car tires. Artificial grass with infill of rubber granules has become a significant problem with concerns for health, environmental toxins, and microplastics (Aas, 2022, p. 7).

Dissemination of information to the public through emails and Excel sheets is arguably no longer the best practice, and the digitalisation process is not necessarily costly. In recent years, the availability of visual software development tools that can be adapted to the desired use has increased. Such software can further contribute to an increased incidence of data-driven decisions in an age where utilising accessible data is more critical than ever. Data-driven decisions are a part of shaping the future of a more technical and digitalised society.

1.1 The Norwegian artificial turf market

The Norwegian artificial turf market has grown significantly over the last 40 years (Aas, 2022, p.2, translated). The extensive development activity has led to intense price competition, resulting in a narrow focus on the initial purchase price, but to a lesser extent the operating costs and thus lifetime costs. One effect of this competition is that offered systems have had an increasing content of cheap synthetic infill while more durable product elements such as damping mats have been limited or phased out. "This development has resulted in higher maintenance costs as a proportion of lifetime costs, yet it has gone almost unnoticed by the market" (Aas, 2022, p. 6, translated). KG2021 states that the increasing focus on sustainability and environmental requirements for artificial turf facilities "require a better understanding of the costs throughout the facility's life, not just the investment cost" (see *task description*).

KG2021 has developed lifetime-cycle costs (LCC) analyses on artificial turfs to support sustainable and environmentally friendly purchases in the future. The purpose is to ensure a better longevity economy for new procurements, as such models have, to a small extent, been developed for this sector so far. A total of 37 analyses have been prepared based on the same number of tenders from six different suppliers in the Norwegian market. Lifetime-cycle costs (LCC) is an economic factor used for analysing and calculating the costs of investing in construction and buildings. The term LCC is a

measure that illustrates the premises of owning, maintaining and developing the construction per year (DFØ, 2022).

1.2 Research on sports facility managers

The study "Future Sports Facilities - organisation, management and leadership", conducted by the Sports Analysis Institute and the Centre for Research in Sports, Health and Civil Society (CISC) at the University of Southern Denmark, has identified several findings by interviewing sports facility managers (Iversen et al., 2019, p.8). Although the study is from Denmark, it is relevant for us as both the artificial turf market and the population is similar to Norway. Most sports leaders have short vocational educations, whereas 83% have no experience in managing sports facilities beforehand. Furthermore, the report states that although they understand that municipal and national enterprises are interested in creating added value for the entire local community, there is a clear tendency that they are unable to translate thoughts of public value into action. They, therefore, need, among other things, clearer objectives so that they know which activities and initiatives are to be prioritised for implementation and monitoring.

1.3 Our project description

KG2021s LCC analysis of the 37 artificial turfs is meant to be a tool to support an increase of objective knowledge among decision-makers about materials and project implementation, environmental impact, and thereby increased ordering competence. Therefore, this bachelor thesis aims to support the presentation of prepared LCC analyses by developing a digital application where potential buyers can compare different tenders and their life cycle costs. One should readily be able to see what constitutes the total price and sort the presentation by relevant parameters; price and types of infill in the artificial turfs. Furthermore, it is essential to mention that KG2021 is a non-profit project, which also sets particular requirements for the application, of which perhaps the most important is that the application should be free of cost to display. It must also be virtually "maintenance-free", as KG2021 are not full-stack developers and do not possess the capabilities for managing servers and databases.

1.4 Research aim and questions

Our project encapsulates two aspects. On the one hand, we will develop an interactive application that conveys the LCC analyses that KG2021 has prepared. As part of our bachelor project, we are responsible for managing the entire project, from the concept to integration. On the other hand, we must also seek to address KG2021's objectives with the application. Their goal is that the application contributes to an objective increase in knowledge and enables a more environmentally friendly and economically sustainable artificial turf market. Therefore, the problem definition of this thesis is:

"Developing an accessible technical tool to disseminate and use KG2021's research, aiming for environmentally and economically sustainable football pitches through appropriate design choices"

For this problem we have the following research questions:

- **RQ 1:** Will the tool be accessible?
- **RQ 2:** Will the tool have the usability to support dissemination of KG2021's research?

1.4.1 Delimitation

It is a requirement for the application that it should be easily accessible across professional and organisational boundaries and technical infrastructures. We therefore decided to avoid coding from scratch, and instead use off the shelf software, which we address further in *chapter 3.2*.

Furthermore, we will not, given the short project period, aim to validate whether the application actually, over time, contributes to a more environmentally friendly and economically sustainable artificial turf market. However, it does include addressing the context of use for the application and what its purpose is.

2. Theory

2.1 Insights into the artificial turf industry in Norway

The artificial turf market in Norway has been growing for the past 40 years. Newly built facilities have varied in infill in the latter years due to the environmental focus aiming for a phasing out of turfs with synthetic infill (Aas, 2022, p. 5, translated). A particular driving force in this development has been the Norwegian Environment Agency (NEA), which proclaims that "Rubber granules from artificial turf pitches are believed to be the second-largest land-based source of microplastics in Norway" (NEA, 2021). Therefore, regulations have emerged where NEA in 2019 introduced regulations for the handling of rubber granules at all facilities in Norway to reduce the spread of synthetic infill from the facilities (Forurensningsforskriften, 2021, §23A). The estimated cost was 1.6 million NOK for an 11-a-side pitch (Aas, 2018, p. 8, translated).

Consequently, nearly 50% of the providers of turfs announced projects without the need for synthetic infill. The underlying reasons for this are the increasing demands for sustainability and a focus on LCC (Aas, 2022, p. 5, translated). In addition, subsidy schemes have become more prudent in providing economic support for pitches without synthetic filling (Aas, 2022, p. 5, translated). KG2021's research also shows some other positive effects of the changes in the market. Rather than seeing a continuation of the current rate of artificial turf establishment, a focus on renovation and maintenance of existing pitches is expected (Aas, 2022, p. 5, translated).

2.2 The structure of the LCC analysis

The starting point for our application development is the data set with the LCC analyses originally established by SIAT in a spreadsheet. All variables in the application- e.g., TOTEX, CAPEX, and OPEX are taken from this dataset. In addition, there are several other variables for calculating the LCC cost, which are gathered from the same data set, which will be explained in *chapter 2.2.1.*

TOTEX

The LCC analysis produces the total cost over 10 years, known as Total cost of Expenditure (TOTEX). TOTEX is composed by adding Operating Expense (OPEX) to Capital Expenditure (CAPEX) + Environmental costs, in this case.

- Environmental costs due to the NEA regulations. Applies to facilities with synthetic infill to prevent the discharge and spread of synthetic infill from the football pitch area.
    - The costs derive from a physical barrier around the pitch, solutions for handling the spread via drainage and surface water, and solutions that prevent users and construction machinery (during maintenance) from spreading the material.

$$TOTEX = CAPEX + OPEX + Environmental\ costs$$

CAPEX

Capital expenditure is an economic variable used for calculating the costs of acquiring and maintaining an asset, typically property, buildings or technology (Fernando, 2022). In this case:

- Disposal cost of artificial turf. The cost occurs when the artificial turf is to be removed, and is affected by environmental regulations.
- Installation of shock pad if necessary.
- Installation of the artificial turf including eventual infills needed (sand, organic or synthetic).

$$CAPEX = price\ of\ new\ system + disposal\ of\ the\ existing\ turf$$

OPEX

An operating expense is the regular cost of running a business (Kenton, 2021).
In this case this includes all maintenance costs over ten years:

- General maintenance needed. It includes annual deep cleansing and periodic brushing of the turf.
- Refilling of infill based on supplier's measurements. Infill consisting of both synthetic, organic, and sand must be refilled, where the amount varies greatly according to the type and the facilities infrastructure.

$$OPEX = 10\ year\ maintenance\ cost$$

2.2.1 Other variables

There are several other variables in the existing dataset. Some variables are too specific for the application users to understand the meaning of, consequently omitted from the application. Some factors are also included in the LCC analysis as mentioned above.

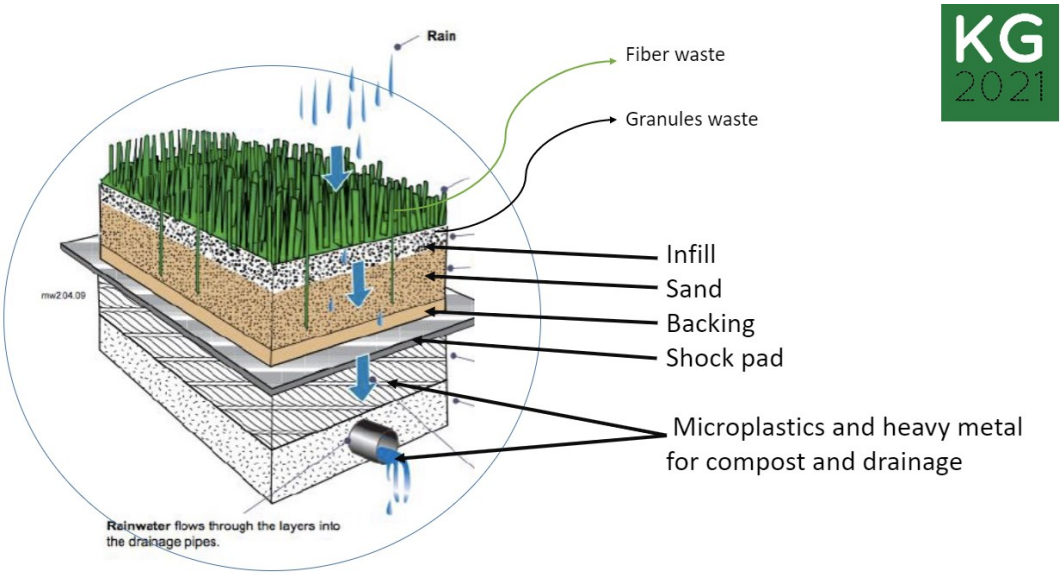

Figure 1- artificial turf as a system (Aas, 2021a).

Surface area

The size of a football pitch is mainly categorised according to the number of players the pitch is intended for. Typically, the football pitches are called, e.g. X-a-side, where X represents the number of players on one of the two teams. X is typically 11, 9, 7, 5, or 3. Although the square metres may vary, all football pitches in the LCC analyses are calculated as 11-a-side. Because of this, we opted to not include filtration on size in the application.

Nordic Norm

This term relates to certifications and standards of the different artificial turfs. The European standard, EN15330-1, serves as a reference point for product quality and -characteristics for the different ball sports (Aas, 2022, p. 2, translated). The purpose of the standard is to ensure the correct quality for each particular sport. Particularly relevant for sports organisations is that almost no subsidies are given to football pitches that are not certified. Our original data set differentiates between A, B, C, and D certifications, where each letter represents a particular type of infill.

Infill type

As illustrated in the picture above, infill is the first layer of the surface beneath the fibre and granules. The infill is one of four categories, per nordic norm; synthetic, organic, sand, and non-infill. Each of the categories consists of several different subgroups, see Table 1.

Synthetic	Organic	Sand	Non-infill
Styrene-butadiene (SBR)	Cork	Sand	Non-infill
Thermoplastic (TPO) and (TPE)	Olives		
Biobag	Coconut/Cork		
Bioflex			
Bioflow			
EPDM			
Biosand/Olives			

Table 1- comparison of the different infills

On the other hand, infill is usually categorised according to the height of the artificial grass fibres and stitch rate[1], as different standards and applications require different heights. This approach comes down to the purpose of infill (Standard Norge, 2020, p. 4):

- It is used to stabilise the carpet to prevent dimensional expansion and contraction and movement through use i.e., it acts as a ballast. This type of infill is often described as stabilising infill.
- The performance type infill is a crucial component of the surface as it provides comfort and protection to players as they run and fall on the surface. It contributes to or provides the sports surface's performance and impact attenuation characteristics. This type of infill is often described as a performance infill.
- It helps control the way the ball interacts with the surface, supporting the pile of the surface so it remains upright.

Synthetic infill is polluting and especially troublesome when migrating to locations outside the facilities (Standard Norge, 2020, p. 5). About six per cent of the rubber granulation ends up off the tracks every year (NEA, 2021). This migration directly results in typically higher costs when refilling synthetic infill and also makes synthetic infill have higher maintenance costs than the alternatives, as established by KG2021 (Aas, 2022, p.9, translated).

Shock pad thickness

The shock pad is a pad that lies beneath all of the infill, fibre and these layers. The shock pad is the construction that shapes the size of the pitch. The shock pad can either be

[1] Number of tufts per square metre (Standard Norge, 2020, p. 5)

prefabricated or cast locally in the exact place. The shock pad also comes in different thicknesses and varies from system to system.

Environmental upgrade costs

These costs address the implementation of the measures in accordance with NEA's environmental measures, as presented by division in 2.2. The cost is included in TOTEX, but not in CAPEX or OPEX, as assessed by KG2021.

2.3 Change management- for establishing new practices

Change management is a broad subject. Most relevant for this thesis are changes in processes that include changes in decision-making, production, communication, and education (Jacobsen & Thorsvik, 2015, p.385). The purpose of developing our application, implying the introduction of a technical tool, is to contribute to an objective increase in knowledge, enabling a more environmentally friendly and economically sustainable artificial turf market by disseminating KG2021's research. Specifically, we want to improve how decision-makers obtain their information before investing in facilities. Hopefully, a presentation of the LCC data using visualisation techniques with its complex relationships will make it easier for decision-makers to make sustainability informed decisions. Our approach must be seen in the light of CISC's report, which confirms that decision-makers struggle to address sustainability in their decision-making process.

2.3.1 Digitalisation

Digitalisation is a term with several definitions. Nevertheless, a critical aspect that is repeated in several definitions is that beneficial digitalisation means the transformation of socio-technical structures[2] that were previously mediated by non-digital artefacts or relations to such, which are mediated by digitised artefacts and relationships (Osmundsen et al., 2018, p. 3). Our application development deals with developing a user interface (UI), where UI is the point of communication between a human and a device, for instance, between a human and a computer's desktop (Churchville, 2021). Knowing that the average Danish sports manager is 52,5 years old and has a lower education (Iversen et al., 2019, p.8), it is wise to develop a user interface that limits the need for prior expert knowledge. Therefore, it is a goal for us that the user interface and user experience should be straightforward, easy to use and can run in a software environment that makes it accessible to use without extra cost. The aim should be for the new tool's adoption threshold to be low, and that any change of habits, compared to current work processes, should be easy. It might also be helpful to have in mind the socio-technical structures of the processes of introduction and support for motivation of use and for the continued use of the application over time, might require attention.

[2] In organisational development, a socio-technical system is a system where people and technology must interact in order to get work done (Rydland, 2021, translated).

2.4 Data-driven decision making (DDDM)

Data-driven decisions are based on facts and data rather than assumptions. The process consists of retrieving data and identifying trends and facts from the data, which one then applies in decision making. The purpose is to minimise the risk of making poor decisions. The subject area is large and somewhat perplexing and is often linked to the concept of business intelligence (BI). BI involves the frameworks, methods, or processes that improve decision-making using fact-based systems (Trieu, 2017; cited by Kimerud, 2021, p. 11). Furthermore, some research claims that 70-80% of all BI initiatives have failed (Goodwin, 2011; Kimerud, 2021, p. 11). Previous literature that tries to explain how IT investments bring value indicates that one must understand how the underlying processes function as a basis for investments to add value to an organisation (Markus & Soh, 1995; Melville et al., 2004; Schryen, 2013; Kimerud, 2021, p. 11).

After the end of this project, whether our application will contribute to a more data-driven decision-making process will be something KG2021 must consider in the long term. In this case, KG2021 has already decided that it is desirable to have a technological solution as a tool for objective knowledge increase among decision-makers. On the other hand, we as developers also need to be aware of the goals the application should contribute to and how it is intended to achieve value. This kind of insight will help shape our solution.

2.5 Knowledge

Knowledge can be defined as the unique information possessed in the mind of individuals related to facts, procedures, concepts, interpretations, ideas, observations and judgements (Alavi & Leidner, 2001). Where KG2021 wants to increase ordering competence. Fontinha (2019, p. 8) cites that "According to researchers Mohayidin, Azirawani, Kamaruddin and Margono (2007) knowledge is developed and spread through all organisations as a basis of value development. Hence, over time, knowledge has become an asset with value into organisation". Therefore, it can be argued that the application will help spread KG2021's set of values as a basis for a new practice in the industry. The application will then function as a catalyst, in addition to the information one should be able to acquire from it.

Knowledge transmission occurs whenever knowledge is diffused from one individual to another through socialisation, education and learning (Alavi & Leidner, 2001; Ou et al., 2014; Yang, 2007; Fontinha, 2019). More specifically, both conceptual and empirical studies have suggested that the stronger the ties and trust, the easier it will be to transfer knowledge (Ou et al., 2014; Fontinha, 2019).

2.6 User centred development

The ISO standard 9241-210 ”Human-centred design processes for interactive systems”, describes user-centred development as a process based on the active involvement of users throughout the process with the aim of a better quality of use (Følstad & Skjetne, 2007, p.4). We have adopted an interpretation of the methodology, as the scope of this

thesis deals with more than just user-centred development. Therefore, it is limited by how closely one can follow a set development process within the time frame of the bachelor thesis. The ISO standard defines six principles for user-centred development:

1. Design is based explicitly on understanding the user, tasks and environments.
2. Users are involved in the design and development process.
3. The design is driven and further developed by user-centred evaluation.
4. The process is iterative.
5. The design addresses the entire user experience.
6. The design team consists of interdisciplinary expertise and perspectives.

These six principles form the cycle of user centring, consisting of four iterative activities, as shown in figure 2 (International Organization for Standardization, 2019).

1. Specify context
   Identifies the user, how they want to use the product and what context
2. Requirements specification
   Identifies user needs and requirements for a satisfactory product
3. Develop design proposals and prototypes based on the previous phases
4. Evaluate the design.

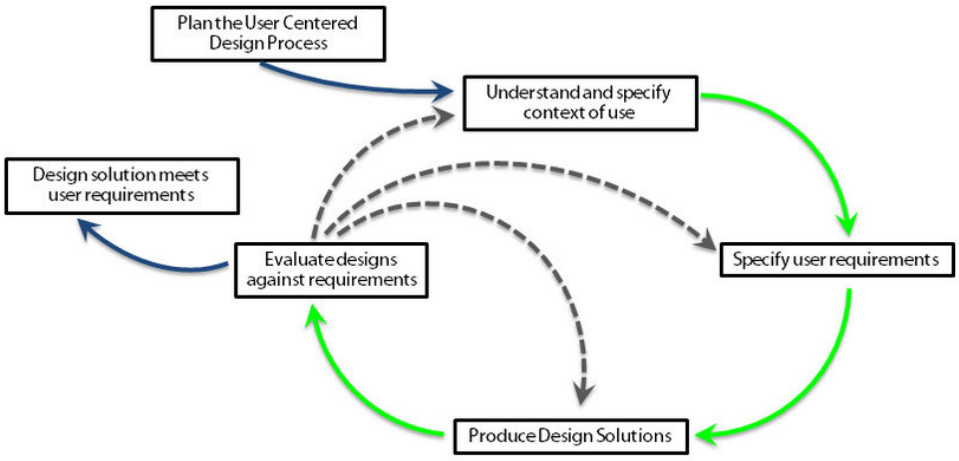

Figure 2- user centred development (ResearchGate, n.d)

A user-centred development methodology transforms users' needs and goals into comprehensive application solutions. The term user-centred design is widely used; in this context, it is more about the human aspect than the technological. It is thus about how one takes care of needs, wishes, and limitations during the process. The process is iterative, with its benefits, intending to ensure a result that fits the users and sites of use. By developing prototypes and involving the user in their evaluation the risk of misunderstandings is reduced.

Degrees of involvement

Different strategies of user-centred development have different degrees of user involvement. The difference is how one acquires information about the end-user, which further influences the development choices.

- With a user-centred approach, one acquires knowledge via observation, interview, and mapping.
- In a user-involved approach, one acquires information via direct feedback from the user.
- In a user-participating approach, one acquires information by the users actively participating with their ideas as participating developers throughout the process.

Personas

We have created personas as part of the user-centred development. The concept of "persona" was launched by A. Cooper in 1999 (Cooper, A., 1999). A persona is a realistic hypothetical user where one describes this person's goals, interests, habits, and demographic information. The personas serve as a tool for developers to stay focused on the actual needs of the end-users. Furthermore, the personas approach is often combined with other techniques in user-centred development (Grudin & Pruitt, 2002), as in this case. See *chapter 9.1* for the description of the personas.

The following guidelines were applicable when we designed the personas (Usability, n.d):

- Represent a primary user group for the website
- Express and focus on the significant needs and expectations of the most important user groups
- Give a clear picture of the user's expectations and how they are likely to use the site
- Aid in uncovering universal features and functionality
- Describe real people with backgrounds, goals, and values.

3. Technology choice and development method

3.1 Our development and research method intertwined-informed by Design Science Research

Our work is based on the design science research (DSR) paradigm, "in which a designer answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of scientific evidence" (Hevner & Chatterjee, 2010, p. 5). Oates (2006) refers to DSR as a design and creation research strategy that develops new artefacts. From both of these definitions, one can conclude that DSR is concerned with creating an artefact or instantiation that solves or addresses

a specific problem. In this case, how implementing a user-friendly digital dashboard can contribute to disseminating KG2021's findings and objective knowledge increase among decision-makers.

The DSR framework was found to be an appropriate paradigm for this thesis, considering our project. Furthermore, Vaishnavi and Keuchler (2004) describe DSR as specific techniques that complement the positivistic and interpretivistic perspectives in Information Systems (IS). DSR involves analysis of the usability of created artefacts, and therefore this process may involve methods used by both interpretive or positivistic research paradigms. Therefore, the methods also include dimensions from interpretive paradigms, such as qualitative methods used in data collections in the iteration process, thereby understanding the overall project.

Informed by the DSR paradigm, and theory on user centred development, we have used an iterative development process in close collaboration with the KG2021 representative to inform the relevant perspective in formulating requirements for a dashboard. Furthermore, we have created personas and performed user testing to develop the solution and inform users of the issues of sustainable use.

3.1.2 Design and Creation

Oates (2006, p. 35) defines design and creation as a research strategy. In information technology, the design and creation strategy often focuses on analysing, designing, and developing an electronic product. It is used when the research requires producing a new element of a system or a system as a whole (Oates, 2006, p.109). The resulting products from the strategy can be artefacts, models, or constructs. Whereas artefacts can include working instantiations demonstrating how suggested models, methods, or constructs can be implemented using ICT (Hägglund, 2009, p.32). Furthermore, the artefact will manifest itself as an instantiation, where instantiation is defined as a usable product that displays how theories or methods have been integrated into a computerised system. Applied theories and methods, in this case, will be DSR, user centred development, principles from Human-Computer Interaction (HCI), LCC analysis, and literature on sports facilities, primarily football.

Designing and creating new IT products or services represent an approach to solving a problem (Oates, 2006, p. 111). In our case, KG2021 has, in order to disseminate their research of KG2021, asked for an application. Our objectives include designing an interactive application to enlighten the clientele of KG2021 further. In order to have an extensive information base, observation and document data were key informative sources, together with an ongoing dialogue with KG2021 when our prototype was iteratively developed.

3.2 Requirement specification

The KG2021 request and task proposal were that we should find a way to visualise their developed LCC analyses in an accessible and user-friendly way. It is in connection with their goal of a more environmentally friendly and economically sustainable artificial turf market. Hence, the design was a crucial element to highlight.

To meet the request for KG2021, we started the work of clarifying the requirements specifications for the application. The requirements specifications address what KG2021 expects from the application while setting the framework we must comply with. Through an ongoing and iterative process with the project leader, the following requirements were set:

- The solution must be free of cost to use, also in the foreseeable future.
- The application should be based on off the shelf software and not programmed from scratch.
- The application must be virtually maintenance-free to ensure that the application is updated and works after our delivery.
- KG2021 should be able to easily update the data content, and adapt the application to necessary use - if the purpose changes after our delivery. For example, minor changes to the content and design of the application - while not wanting to deal with programming.
- The solution should be easily accessible to users and should have the ability to be integrated into the website of KG2021.
- Only KG2021 should be able to manipulate the application and the data behind it.

We dedicated much time to this fundamental process before choosing the type of application and software supplier, before starting the development process.

3.2.1 Further explanation of the requirement specification

Secure

Any application development should include the security aspect early in the planning. We applied Bergsjø & Windwik's (2020, p. 22) definition of digital security; "three overall goals: confidentiality, integrity, and availability". Integrity and availability were necessary to implement, as KG2021 wanted control over who could edit, view, and manage the application and dataset. That is, the ability to differentiate access levels of users.

Availability

It was an explicit requirement that the application had the opportunity to be integrated into KG2021's website. Many suppliers offer this, but typically with reservations. Either for a fee or by users having to create a user profile before using the application. We ruled out such solutions, as they go at the ease of use and the free-of-use requirement.

Free of use

The application should be free in the foreseeable future. Including:

- Regular use of the application. When scaling to more users, the cost should not increase.
- Integration of the application intended for public use. Software suppliers typically have a distinction between internally integrated applications and applications that the public can use on public websites.
- Cloud data storage options for the LCC analyses.

User experience and -interface

The application must be user-friendly and have a good user interface. Furthermore, it was desirable that:

- KG2021 can make minor changes to the user interface and design using visual "drag-and-drop" programming. The reason for the requirement is that the purpose and dataset of the application may change at a later date.

Maintenance

The application should be virtually maintenance-free so that KG2021 does not have to worry about updates to drivers, components, servers, back-end-related challenges, and network line capacity.

3.3 Type of application

Taking into account the requirements specifications, we found that a dashboard-like solution was a suitable application type. Furthermore, we both had experience with dashboards and some overview of different software providers and their functionality.

A dashboard in the business community is recognised as an emerging performance management system, for example, to monitor productivity, analyse cost-effectiveness and improve customer satisfaction (Eckerson, 2010; Park & Jo, 2015, p. 112). Moreover, Key Performance Indicators (KPIs) are often displayed so that decision-makers can receive alerts as to whether the performance has deviated from predefined targets (Podgorelec & Kuhar, 2011, p. 112). A typical dashboard of quality should present detailed information of performance indicators, without using too many drill-downs[3] (Lasota, 2020). Furthermore, identifying trends and patterns can stimulate future process improvements (Lasota, 2020).

However, the definition of dashboards has outgrown itself over the past decades. A dashboard is a "visual display of the most important information needed to achieve one or more objectives consolidated on a single computer screen so it can be monitored at a

3 A drill-down is a filtering function to narrow the search of a dashboard or report, providing the user with more specific information for that selected filter (Yellowfin, n.d)

glance", as described by Few some years ago(Few, 2013, p. 26). With the evermore expanding data volume, big data applications and consumer technology, dashboards pursued to be SMART (synergetic, monitor KPIs, accurate, responsive, and timely). IMPACT (interactive, more data history, personalised, analytical, collaborative, and traceability) was also a focus point (Malik, 2005; Park & Jo, 2015, p. 112).

With the purpose of this delivery project, a dashboard was considered a good tool for achieving the project goals. In particular, it is emphasised that dashboards are designed to display KPIs user-friendly. Additionally, they are primarily easy to maintain and easily integrated with, for example, websites and various types of datasets. On the other hand, it is worth mentioning that many dashboards are meant to show a continuous live feed of relevant data. Power consumption, traffic of several kinds, financial income and expenses are examples of this kind of data. That is not the case in this thesis. Instead, the developed application will emphasise interactivity, ease of use, and accessibility. The database will be static, only updated when KG2021 expands it with more LCC analyses.

3.4 Choice of software supplier

3.4.1 The different options

After determining the application type and requirements specifications, the search for software options began. We simply started by googling "dashboard software", and worked our way through. Table 2 shows relevant software suppliers compared to the requirements specification.

	Tableau	**Google Data Studio**	**GoodData**	**Grafana**	**PowerBi**
Secure	☑	☑	☑	☑	☑
UI & UX	☑	☑	☑		☑
Free to use		☑	☑		
Embedding		☑			
Score	**2 / 4**	**4 / 4**	**3 / 4**	**1 / 4**	**2 / 4**

Table 2- comparison of the software suppliers

Based on our software supplier analysis, with results displayed in table 2, we chose Google Data Studio. There may be several providers who also meet the requirements, but they have not been identified. Furthermore, there are several benefits to Google Data Studio, described in the next *chapter 3.4.2*.

3.4.2 Google data studio

Google Data Studio is the dashboard solution for Google. They describe it as "a free tool that turns your data into informative, easy to read, easily share, and fully customisable dashboards and reports" (Google, 2022b). Furthermore, they highlight the functionality their drag and drop editor can be used for:

- "Tell your data story with charts…"
- "Make your reports interactive with viewer filters and date range control"
- "Annotate and brand your reports with text and images"
- "Apply styles and colour themes that make your data stories works of data visualisation art"
- "Easily connect to a variety of data sources"
- "Share insights with the team or with the world".

The data connection options are good and directly integrated with Google Drive. By using Google Data Studio, one gets access to an ecosystem from an excellent company. This has reassured that the application's terms, seen against the requirements specification, will not change - something one can expect from less established companies to a greater extent.

Another advantage of Google is that all services are based on the design platform Material Design, initially developed by Google. "Material is an adaptable system of guidelines, components, and tools that support the best practices of user interface design" (Material, 2021). The purpose is to unify the user experience across applications and platforms, where the software is open-source and accessible to everyone. The components of our application, both graphical and functional, will therefore be based on proven functionality. Furthermore, it is advantageous that probably all users of our application have experienced several interactions with some of Google's platforms and thus can recognise the functionality more quickly. Additionally, Material Design has freed up time because we have not had to focus too much on responsive design. For example, our application is universally designed and is scaled correctly to all devices and browsers.

Google data studio has some negative aspects. Mainly the lack of conducting predictive analyses. For example, it is impossible to predict LCC analyses by user-based input. The weakness is mainly not related to the lack of machine learning but rather that the software offers limited custom logic. It was possible to use user input with straightforward visualisations, such as the user entering two and the output being four. The shortcoming was that restrictions on other logic, such as If / Else statements, could not be connected to values in the dataset. This functionality was only found in paid software, nor was it a requirements specification. Furthermore, other available and unavailable features were not used, as our dataset was relatively limited, and the functionality was thus not relevant.

3.5 Cleaning the dataset

KG2021 gave us an excel sheet with 37 pitches and LCC analyses to visualise. It looked like this:

	LCC of artifical turf		1	2	3	4	5	6	7
3	Surface area	m2	7208	7208	7208	9032	6000	7000	7208
5	Nordic Norm		A	A	A	A	A	A	
6			3G	3G Biopolymer	3G	3G	3G	3G	3G
7	Surface area	m2	7208	7208	7208	7208	7208	7208	7208
8	Fiber height	mm	45	35	42	42	30	30	
9	Shockpad thickness	mm	12	12	12	10	20	10	10
10	Infill		TPO	Biobag	TPE	SBR	SBR	SBR	SBR
11	**Disposal of existing turf**	**kr**	**471 175**	**-**	**-**	**449 246**	**340 256**	**340 256**	**352 972**
12	**Specific price**	**kr/m2**	**65**	**-**	**-**	**62**	**47**	**47**	**49**
13	Installation works	kr/m2		35	35				
14	Turf	kr/m2		310	140				
15	Pad, 12mm	kr/m2		51	65				
16	Pad, 30mm insitu	kr/m2							
17	Sand	kr/m2		22	23				
18	Infill	kr/m2		62	129				
19	Unit price total	kr/m2	455	480	392	212	293	249	259
20	**Price new system (CAPEX)**	**Kr**	**3 279 244**	3 459 840	**2 825 536**	**1 526 408**	**2 111 944**	**1 794 792**	**1 898 872**
21									
22	**Annual maintenance**								
23	**Refill annually**	tonn/år	1,0	1,4	2,0	3,0	3,0	3,0	4,0
24	**Refill annually**	kr/år	28 000	42 000	56 000	84 000	84 000	84 000	112 000
25	Annual deep cleaning	kr/år	20 000	20 000	17 500	17 500	17 500	17 500	17 500
26	Weekly maintenance	kr/år	312	312	312	312	312	312	312
27	**Total maintenance cost in 10y (OPEX)**		**455 120**	581 120	**682 120**	**934 120**	**934 120**	**934 120**	**1 186 120**
28	Environmental upgrade costs	Iflg Miljødir	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000
29	***Total cost of ownership (TOTEX/TCO)***		**5 205 539**	**5 040 960**	**4 507 656**	**3 909 774**	**4 386 320**	**4 069 168**	**4 437 964**

Figure 3- the LCC dataset provided from KG2021

The dataset was somewhat incomplete, and several pitches had cells without values. We, therefore, cleaned and standardised the dataset in a new copy before we started with the development of the dashboard. The purpose was that the visualisation should not be based on incomplete material so that the users in the application misunderstood the material. See Figure 4 below.

Pitch nr	Size	Type	FiberHeight	Shockpad	Infill	DisposalPrice	DisposalM2	UnitPriceTotal	CAPEX	RefillAnually/Tonnes
1	7208	A	45	12	TPO	471 175 kr	65	455	3 279 244 kr	1,00
2	7208	A	35	12	Biobag	367 608 kr		480	3 459 840 kr	44 652,00
3	7208	A	42	12	TPE	367 608 kr		392	2 825 536 kr	2,00
4	9032	A	42	10	SBR	449 246 kr	62	212	1 526 408 kr	3,00
5	6000	A	30	20	SBR	340 256 kr	47	293	2 111 944 kr	3,00
6	7000	A	30	10	SBR	340 256 kr	47	249	1 794 792 kr	3,00
7	7208	A		10	SBR	352 972 kr	49	259	1 898 872 kr	4,00
8	7208	A	35	14	Bioflex, 20mm, 140t	471 175 kr	65	400	2 883 200 kr	2,00
9	7208	A	35	14	Bioflex, 20mm, 140t	471 175 kr	65	466	3 358 928 kr	2,00
10	7209	A	35	14	Bioflex, 20mm, 140t	471 176 kr	65	443	3 193 144 kr	2,00
11	6000	A		12	Bioflow, bioplast+hamp	274 400 kr	38	375	270 300 kr	2,00
12	7208	A		10	SBR	490 144 kr		275	1 980 038 kr	3,00
13	7208	A		12	SBR	367 608 kr		312	2 248 896 kr	3,00
14	7208	A	42	12	EPDM	367 608 kr		338	2 436 304 kr	3,00
15	7208	A	42	12	SBR	367 608 kr		283	2 039 864 kr	3,00
16	7208	A	40	20	EPDM	300 000 kr		367	2 644 327 kr	4,00
17	7208	A	60	Ingen	SBR	367 608 kr		255	1 838 040 kr	3,00

Figure 4- the dataset cleaned

The pitches are categorised according to the Nordic norm and, therefore, the type of infill[4]. There were originally four categories. We removed the last category in the

4 See chapter 2.2 for an explanation.

processed dataset, as the data only consisted of one pitch that had too much missing information. Likewise, the turfs in category C did not have data about refills annually, and our dataset is not complete with every cell filled with data. On the other hand, we have structured the dataset so that KG2021 can quickly fill in future pitches with LCC analyses. The processed dataset could now be used to its full extent and function as in-data for further development of the dashboard.

3.6 Our development process

The DSR framework iterates between five phases: awareness of the problem, suggestion, development, evaluation and conclusion (Terblanche, 2013, p. 14), as illustrated in Figure 5.

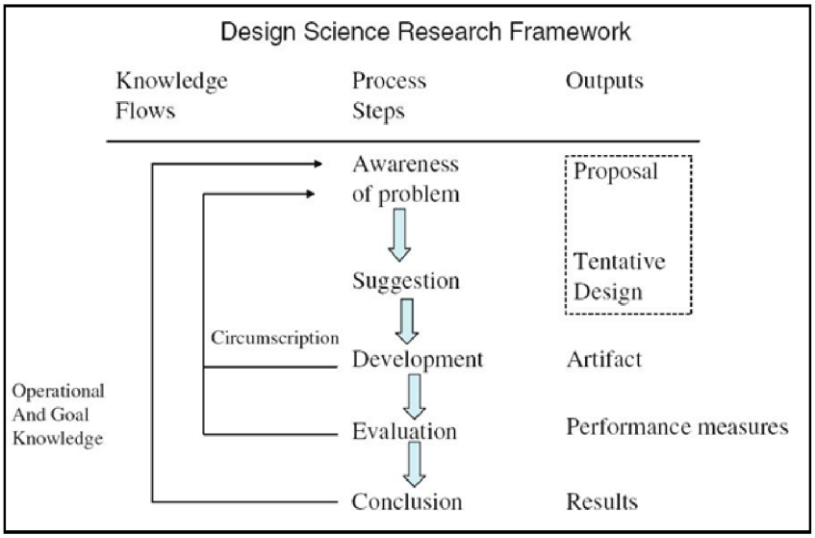

Figure 5- the DSR framework

3.6.1. Awareness of the problem

In this phase, one becomes aware of the initial applicability problem. In this study, the initial problem was the lack of knowledge concerning the results of KG2021, resulting in this thesis assignment. Nevertheless, it became clear through thorough discussion that this academic thesis problem is:

"***Developing an accessible technical tool to disseminate and use KG2021's research, aiming for environmentally and economically sustainable football pitches through appropriate design choices.”***.

As mentioned in *chapter 1.3*, the non-profit environment defines a clear framework for application development. A total of five meetings were held with the project manager for KG2021 before we landed on the requirements specifications mentioned in *chapter 3.2*, which led us to propose a dashboard solution. After setting the requirements specification, we started with the software supplier search before moving to phase 2. Furthermore, the application needed to be adapted to the correct user group during the iterative development work, and we, therefore, carried out a stakeholder analysis.

Stakeholder mapping

The purpose of the mapping is to uncover who can influence the result and outcome of the project, both negatively and positively. The project stakeholders often have information, resources, and preferences for the product. A stakeholder is anyone who has an interest in your project or with whom you need to work with in some way to complete the project (Savina, n.d). Stakeholders in this project were KG2021, the supervisor, the end-users, and the development team.

ID	Stakeholders	Interest	Power
S1	KG2021	High	High
S2	Supervisor	Moderate	High
S3	End-users	Low	High
S4	Development team	High	High

Table 3- comparison of the stakeholders

S1 KG2021

KG2021 is the client of this project. Communication has been vital to take care of to ensure that the application contributes as much as possible to their goals. Therefore, we have communicated closely with their project manager, informing him about our progress, showcasing prototypes, and discussing solutions.

S2 Supervisor

Our supervisor has been Kirsti Elisabeth Berntsen. She has assisted with valuable expertise and guided us through the project work, especially within reporting. Due to her competence, the influence and power has been high, as we wanted to follow her guidance as much as possible.

S3 End-users

The main design of the application is based on end-users quickly acquiring information. Therefore, there has been a significant focus on usability, accessibility, and user experience. For the same reason, the system development methodology is iterative, with user tests, to optimise the result.

S4 Development team

We, as developers, are also stakeholders. The bachelor thesis has been an excellent opportunity to gain more experience in business development and application development. Furthermore, we naturally have great interest and power to influence the result.

3.6.2. Suggestion

In this phase, we presented a solution for disseminating complex information that will enable an objective increase in knowledge about the factors that make up CAPEX, OPEX, and TOTEX - and hence enable a more environmentally and economically sustainable artificial turf market. Furthermore, our suggestion may or may not be built upon known solutions. “This phase results in tentative design, for example, a prototype” (Adebesin et al., 2011, p. 313). In the case of this study, we presented an interactive Figma prototype of a dashboard to showcase our initial thoughts.

Our initial thoughts, after debriefing ourselves with KG2021 materials and other literature, was that the users of this dashboard would not be familiar with the pros and cons of different artificial turfs and their infill. Therefore, our prototype presents different filters that each user can engage, that in turn presents different alternatives with associated key performance indicators; such as TOTEX and maintenance. In addition, we emphasised that the application, if successful, will change the way decision-makers obtain their information. Therefore, we wanted a simple and accessible dashboard where all the information was on one page, with a user interface that clearly showed the functions of the various components. These features are well aligned with the described desired features from this bachelor thesis task description "... create a tool where LCC can be simulated on the basis of variation of input parameters such as price and quantity, time spent on maintenance … ". For further details, see *task description* in the beginning of this thesis.

After presenting the tentative design, KG2021's project leader was satisfied. We agreed to conduct a supplier search for the software to meet the requirements specifications in the best possible way, before moving on to the development stage. The search became more lengthy than we imagined. It was difficult to determine if the suppliers met the requirements specifications and desired functionality without recreating the prototype by trying out each of the provider's solutions - which we ended up doing in several cases. Ultimately it was decided that Google Data Studio was the preferable software for achieving a technically viable solution.

Furthermore, this phase also revealed that we needed to do a more in-depth analysis of whom the users of this artefact are, iterating back to phase one, where we developed personas (see *chapter 9.1*). We used the acquired information from KG2021's project manager and the research report "Future Sports Facilities" (Iversen et al., 2019, p.8, translated) to create two personas mimicking the assumed target group. That we could frame the personas based on the data from the report is an advantage, since a data-driven approach has advantages over assumptions (Marshall et al., 2015).

3.6.3. Development

In this phase, the suggested solution is developed within the researcher's field of knowledge. By the time we reached this stage, we had prepared the requirements specifications, selected the software platform, cleaned the data, and developed

personas. Furthermore, we had read up on HCI principles, so we did not blindly trust that Material Design gave us an exemplary user interface and a good user experience.

We applied a user-centred methodology in our development, as described in Chapter 2.5. We have worked with prototypes actively, with the project owner acting as an intended user. The advantage is that one can evaluate the prototype and then iterate back to the development work or, for example, the requirements specifications. By working iteratively, one thus reduces the risk of both incorrect communication and unwanted development in the project.

Furthermore, we opted for a user-participating and user-involved methodology to identify the end-user and their needs. In our process, we, as mentioned, created personas based on documentation and user involvement from the KG2021's project leader. We, therefore, had continuously direct exchanges of opinions with a user during our development. We are confident that the development work has significantly benefited from this process, primarily because of the valuable insight provided by the user/KG2021s project leader - even though this knowledge cannot represent all end users. Therefore, the personas have served as additional guidance while developing.

The emphasis on the user interface has not only been about colour choices, the size of buttons and text boxes, and everything else that makes up the application. The use of graphs and tables that are easy to obtain information from, at the same time as users can easily compare figures from different types of artificial turf pitches, has been emphasised. Especially in this part, it was clear that the iterative process worked well, and we implemented continuous changes based on KG2021's project manager's opinion and our experience and theoretical basis. The process was undeniably improved because we had Material Design as a foundation for all our choices. In addition, we noticed that Google Data Studio worked well as software for collaborative development. We could work towards the latest version of the artefact simultaneously as we could keep track of the progress of each other's work.

After successfully presenting a working proof of concept to KG2021's project manager, we decided on crossroads. To ensure the quality of the design of the dashboards, we, two participants, decided to each develop our own version of a dashboard for the user tests. Each of them presented the same LCC analyses - only with variations in design and other information provided. After completing user tests, we used the results for our last iteration and final product.

3.6.4. Evaluation

The produced artefact is analysed and assessed using data-gathering methods in this phase. Ideally, one should use several sources to validate the result - such as user-testing, questionnaires and observation, to evaluate the user-friendliness and effect of the dashboard. However, considering the limited timeframe of this task, questionnaires were omitted. We targeted personas look-alikes from the proposal phase for the user

testing, as the user-centred development is based on them. The artefact can then be tested within the intended scope and field regarding the users.

3.6.5. Conclusion

This phase is reached when a satisfactory artefact is presented. The artefact may not be optimal but offers a suitable solution to the requirements or problem identified. However, as the method is iterative, one should adopt the produced artefact after the evaluation phase in case of the appearance of suggestions while conducting data-gathering - as we did. This is not a conclusion on the academic issue but whether the artefact's functionality is sufficient to contribute to the dissemination of KG2021's findings through an objective increase in knowledge.

According to our development method, one should repeat appropriate phases if one becomes aware of new challenges in the development or evaluation phase. Furthermore, it could be that such a circumscription provides a deeper understanding of both the project objective and the artefact effects on them. We have described the phases where this is the case. In particular, during the user testing, all the test users wanted more context and information related to the LCC analyses, the differences in artificial turf types, and KG2021 in the dashboard.

4. Our research focus and method

We decided to use the design science research methodology under the system development. However, the following paragraphs will explain how we established the research method and gathered the data needed for our project’s main research task.

4.1 The process of defining the problem definition

Deciding on the problem definition has not been easy. At the beginning of this semester, we understood early on that a digital artefact had to be formed. That task was pretty straightforward. On the other hand, we did not know how to connect the theory between developing a technical solution and a relevant problem definition. We ultimately started to write other parts of this thesis and initiate prototype developments, while the research aspect of our problem definition was still somewhat unclear. However, after several meetings with our supervisor, we specified the problem definition to a more relevant extent.

4.2 Research Process

The methodology is the concept of the elementary procedures applied to gain knowledge (Busch, 2013, p.51). As common knowledge has been “accepted” as knowledge because of its research, it is essential to document the methods used. When researching, it is crucial to consider the different approaches and questions during the whole methodology process.

4.2.1 Scientific theoretical starting point

When deciding the choice of scientific theoretical starting point, there are two schools of thought. These are hermeneutics and positivism. Hermeneutics focuses on the fact that there is no such thing as an unbiased reality, only biased interpretations of the reality. On the other hand, positivism explores and uncovers the unbiased reality through a scientific practice (Busch, 2013, p.51). Our method has discovered several aspects. Answers and research discoveries that carry no room for interpretation or misguidance, substantiates the positivistic approach and thus speaks for an uncoloured reality.

Inductive and deductive research is another dimension that describes whether one has expectations about reality or not. Inductive research seeks to gather empirical evidence that later will be interpreted. When researching inductively, one has no expectations or assumptions about the subject. The process develops from empirical to theoretical knowledge (Busch, 2013, p.51).

Deductive research involves using fundamental theory and earlier research to try to answer the hypothesis or problem definition. The purpose is to confirm or refute the problem. As the difference between these two dimensions is pretty distinct, the reality is that one combines the practices in a way called an abductive approach. Abductive means that the scientists alternate between both theory and empirical evidence (Busch, 2013, p.51).

Our approach will be abductive. Since we knew something before, both when it involves artificial turfs, LCC analysis and the variables needed to fulfil the LCC model. On the other hand, we do not know how to increase the lifetime of a football pitch exactly. And we do not know what users will prefer and understand the user interface and data presentation. As this thesis and product will be under development and editing all the time, our approach will lean somewhat towards the deductive method after some time. Our research will be supported by theory, feedback from SIAT, user tests and our own interpretations.

4.2.2 Research design

The next question we have to consider is whether we are using an intensive or extensive design. Extensive involves gathering many data sources, whereas intensive focuses on a few data sources. Intensive design is often connected with the inductive approach and hermeneutics. Extensive is then the opposite. The disadvantage of the intensive design is that the data sources can be poor and affect the research. When one has few sources, the sources have to be deep and insightful to provide enough information.

On the other hand, extensive design gathers much data from different sources, but the problem could be whether the sources progress in-depth in the research. The sources may be superficial. Our approach is similar to the extensive approach, as we both have user-testing, observations and document data.

Our next challenge is the choice of quantitative or qualitative data. Quantitative data gathering is a form of structured data that connects data with statistics and results in the shape of statistical analysis. Quantitative data can be measured and counted in numerical values (Stevens, 2021). Questions like "how many" or "how often" can be answered through quantitative methods.

On the contrary, qualitative data is descriptive and not numerical. The information can be gathered through, for example, interviews and observation. When using this kind of data, the focus is to discover in-depth research and seek specific patterns and behaviours.

Qualitative methods produce more dynamic and subjective data. Even though the results from the qualitative approach have somewhat more difficulty being used in another context, qualitative data gathering is the selected approach. Through user-testing and observation, enough qualitative data was gathered. Since this is also a development project where we physically deliver a final product in addition to this thesis, it is essential to remember that numerical results are not emphasised. Qualitative data is much more suitable as we try to go in-depth and discover the right demands and requirements for our product.

When it comes to time perspective, the option is whether one collects data once or multiple times (Busch, 2013, p.54). Even though our qualitative approach is chosen, a cross-sectional study is an option we chose. We have only user-tested every object once, but that counts as a cross-sectional study. In this case, the tests took place in April 2022. As time is a limited resource, other methods, such as cause-and-effect study, would use too much valuable time for us.

On the other hand, if we did have more time, we would be able to test the objects twice or test even more objects. That would have given us an even deeper insight and understanding. A cross-sectional study will only give us data about the situation at that specific time, so when we deliver this thesis in May, the situation could have been slightly changed.

Our choice of the main design landed on the framework of design science research. This framework is suited for system development, as well as creating and designing an artefact. The methodology has been mentioned in the previous chapter. The table below illustrates the interaction between the DSR-phases and the methods used. The arrow demonstrates the iterative development between the different stages.

DSR-phases	Methods used					
	Documents	Observation w. KG2021	User-testing		Analysis	Iterative dev.
			Observation	Post-test questions		
Awareness	X	X	X			
Suggestion	X	X	X		X	
Development			X	X	X	
Evaluation			X	X		
Conclusion	X			X	X	

Table 4- interplay between phases and methods

4.3 Data Gathering

The following paragraphs seek to define the methods used to gather data relevant to answering the problem definition. Our methods are categorised as qualitative. Therefore, we will not have specific numerical values to display that answer the problem definition but rather numerical results discovered from the post-test questions from the user tests.

NSD- research ethics

At the beginning of this semester, we received an approved application from the Norwegian Centre for Research Data (NSD). The questions and information gathered from this method were saved and stored according to NSD's terms and conditions. It also means that NSD has given us the approval to treat general personal information until 1.6.2022, as long as the participants agree. We did not use recordings in our work.

4.3.1 User testing

One important method for our data gathering is user testing. The testing aims to determine how easy representative users interact with the design by having real users test specific and realistic tasks (Moran, 2019). Usually, it also involves observing users attempting to complete tasks (IDF, 2020).

We had three test persons who were relatively similar to the personas—furthermore, their age, role, and association with KG2021 varied. They were all recruited through KG2021. However, although Nielsen (2019) confirms that it is sufficient to test 3-5 people with a qualitative user test, more access to data on which we could base the results and improve our application would be better - but we decided not to because of the project's timeframe.

4.3.1.2 Test plan

As mentioned in *chapter 3.6.3*, we developed two prototype dashboards to perform the user tests. Both presented the same LCC analyses, with differences in user interfaces, visual diagrams, and other text-based information.

We functioned as facilitators for the test and gave the participants predefined tasks. We observed how they approached the tasks while conducting the task and thinking aloud. We noted all observations. Immediately after the test, we sent follow-up questions to the participants. The purpose of the questions was to get feedback on their preferences and user experience of the dashboards. Furthermore, answering the post-test questions alone and in a less stressful environment can contribute to more honesty and reflection.

We applied the following guidelines for all tests:

- Explain the project and the purpose of the application.
- Clarify that the test's purpose is only to evaluate the artefact and not their technical capabilities.
- Explain that we wanted to be a fly on the wall and did not want to divulge information or help the participant during the tests - so we did not influence the results. At the same time, we encouraged them to think aloud.

The purpose of the results was threefold:

1. We wanted to verify whether the artefact worked technically, whether the users could navigate it, and what preferences they had for the user interface.
2. The results should contribute to our final iteration and improvement of the artefact.
3. We wanted feedback on perceived knowledge increase and what improvements can stimulate more perceived knowledge increase.

4.3.1.2 Tasks and follow-up questions

Dashboard 1	Purpose
Can you display data for only type B turfs? How many turfs are shown here?	The ability to filter via the drop-down menu, and understand that it affects the dataset.
Which OPEX is the lowest on average for the three types?	The ability to restore filtering, and acquire OPEX information from the correct chart. In addition to how they relate to a new definition: OPEX.
Can you find TOTEX for turf nr 12?	The ability to filter on one specific LCC analysis, using the treemap diagram.
Which type of turf is the most expensive overall?	Observation of how they acquire essential information the artefact aims to disseminate.
How many turfs are included in this dataset?	Observation of whether they understand that there is more data for some categories than others.

Table 5- the tasks for dashboard 1

Dashboard 2	Purpose
Can you view data for only synthetic fill paths? How many pitches are shown here?	The ability to filter via the navigation bar, and understand that it affects the dataset.
Can you then filter on all types of infill?	The ability to restore the filtering from the navigation bar.
Can you filter by pitch size 7210[5]. What is the average CAPEX for turf of this size?	The ability to filter via the drop-down menu and understand that CAPEX changes - even within the selected infill category.
Can you filter out turfs with a total price of less than 3 Million?	The ability to use slider filtering and observation of the result.
What does the average Capex consist of?	Observation if they understand this essential definition, and how they acquire info about what it stands for. In addition to the charts they interact with.

Table 6- the tasks for dashboard 2

Post-test questions:

1. On a scale of 1 to 5, how difficult were the test assignments?
2. How would you describe your overall experience with this product?
3. If you could change one thing with this product, what would it be and why?
4. How did you feel about the functionality of buttons and graphs? Was it easy to understand that these were interactive elements? Scale 1-5.
5. Which of the dashboards did you find most neat? Scale 1-5.
6. What was the best and worst thing about the dashboards?
7. To what degree do you feel you have more knowledge about what the costs of owning an artificial turf consists of? Scale 1-5.

4.3.2 Observation / inspection

Observation is a qualitative method used for watching, listening, touching, and recording the behaviour, attitude, and characteristics of objects or phenomena or living beings (Prasanna, 2022). Observation is one of the easiest methods to complete, as little technical knowledge is needed. It is a direct and straightforward method that provides data with higher accuracy and reliability than other methods (Prasanna, 2022).

[5] 7210 specifies the size of the pitch, e.g. 7210 m^2

Wednesday, February 8th 2022, did we meet our client contact at Flatåsen training facility, as Flatåsen is one of the participating facilities in the KG2021-project. The purpose of the observation was to gain even more background information and insight into how a turf is built and see how to preserve it. The project leader showed us around the facility and talked us through the different aspects of owning a turf regarding aspects such as maintenance. We also met the sports facility manager of Flatåsen on our visit, who talked us through the day-to-day activities of the facility.

We chose observation as a method to help us provide enough knowledge and data about artificial turfs. The insight gained from the observation helped us understand that the dashboard could work not only as a helping tool for decision-making but also an extra source of supplementary information that is otherwise difficult to find in other literature or forums.

4.3.3 Document data

Document analysis is a form of qualitative research in which the researcher interprets documents to give voice and meaning to an assessment topic (Bowen, 2009).

When we started this project in January 2022, we received so-called "work documents" from SIAT. These documents are somewhat internal, and they contained necessary information that was useful for us. A total of 19 documents were handed over to us, not everything was quite relevant for us to use, but it provided an overview of the topic and subject.

The project leader sent all these documents to us at the beginning of the semester, which saved us much time as we did not need to find all the relevant documents ourselves. Furthermore, we considered documentation a convenient data source as it is a very accessible and reliable data source (Triad, 2016).

4.4 Analysis of the user test

The data analysis regarding the mentioned method can be seen as how we analysed the answers given after the user tests. The post-test questions from the usability testing are the primary method that needed to be analysed, as observation required no extensive analysing.

The data analysis regarding the mentioned method can be seen as how we analysed the answers given after the user tests. The post-test questions from the usability testing are the primary method that needed to be analysed, as observation required no extensive analysing.

The post-test questions were sent to the participants by email immediately after conducting the tests. The questions required either decree-written answers or assessments from scales 1-5. The numerical assessments were compliant and easy to

visualise using bar graphs. We used contrasting colours to differentiate between the numerical assessments of dashboard 1 and dashboard 2, to increase the overview of the insight.

The descriptive assessments from the post-test questions are directly quoted and formatted into tables so that it is easier to link each participant's assessments to each of the dashboards. The tables also have the same contrasting colours as the chair diagrams from the numerical assessments. The observations from the user tests were immediately written down, as one of us acted as a referent for this purpose only. They are presented as realistic as possible and additionally provided us with new perspectives on user interface and content.

Another form of user testing, which is not qualitative, uses usability metrics. "Typically, usability is measured relative to users' performance on a given set of test tasks" (Nielsen, 2001). Furthermore, Nielsen points out that he recommends as many as 20 user tests to establish a reasonable confidence interval. For this reason, and that qualitative tests often give better results (Nielsen, 2001), we have not used such a method.

5. Results

The results from the user tests came both in written answers to our post-test questions and orally during the test. In addition, we observed how the participants completed the tasks. Below we have summarised the participants. Note that questions and tasks are hereafter abbreviated to Q and T., respectively.

Role according to KG2021	Age	Abbreviation
Has worked with the project a bit	40 years old	P1
Board member of a football club connected to KG2021	51 years old	P2
Project leader	66 years old	P3

Table 7- overview of the test users

The following are the dashboards used in the user tests: Dashboards 1 and 2.

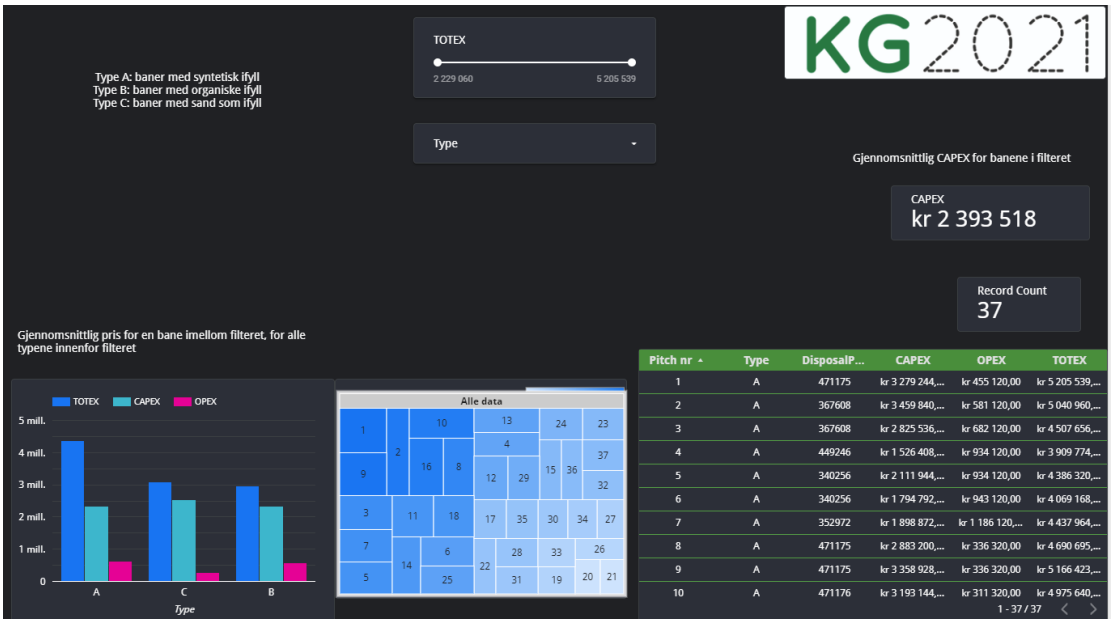

Figure 6- dashboard 1

Figure 7- dashboard 2

5.1 Results from the observation of the user tests

5.1.1 Dashboard 1

T1*:* Can you view data for type B-pitches only? How many pitches are shown here?

The Q1 task was understood by all participants very quickly by using the drop-down filtering with the text "Type".

T2: Which OPEX has the lowest average price for the three types?

Q2 is a more difficult task. The reason is that the filtering by type affects the other tables and graphs. Only P2 understood immediately that one must restore the original state of the filter, i.e. reverse the action in Q1, before one can read the average lowest OPEX for the three types. P1 needed 20 seconds more than P2 on the same process, where P3 needed help with the filter reversal.

T3: Can you find the TOTEX for pitch no. 12?

Q3 is a simple task, and all participants quickly understand that they must interact with the treemap diagram located at the bottom centre.

T4: What type of pitch is the most expensive overall?

Q4 has mixed results. P1 struggled to understand what is meant by the type of artificial turf pitch and wonders if it is about which pitch is most expensive - sorted by number as in Q3. P1 then used the built-in sorting on the table at the bottom right of the dashboard, where he found the most expensive pitch - but not the type. After correction, he understands what is meant by type and then reads the bar graph. P2 also wonders a bit about the question before he understands the purpose of Q4. Then he finds the answer quickly by using built-in sorting in the same table as T1. P3 immediately understood both the question and that he could find the answer in the bar graph.

T5: How many pitches are included in this dataset?

Q5 has divergent results. P1 & P2 wondered a bit about the purpose of the question before concluding that record count accounted for the number of pitches. The last participant had somewhat similar pliers but first tried to identify the number through the treemap filter, which activated filtering on the specific path he clicked on, affecting the record count. After some thought, he managed to remove the filter and found the answer via the record-count diagram.

5.1.2 Dashboard 2

T6: Can you view data for only pitches with Synthetic fill? How many pitches are shown here?

All participants quickly used the navigation bar, which filters the rest of the dashboard and then reads the correct number of pitches from the record-count chart.

T7: Can you then sort on all types of infill? That is, restore the original state.

P2 & P3 immediately manage to remove the filtering from T6. P1 struggled to remove the filter and tried to click around several places on the navigation bar. He stated that by the time he had managed to complete the task, it had been "too long".

T8: Can you sort by pitch size 7210 m^2. What is the average CAPEX for a pitch of this size[6]?

All users quickly applied the drop-down filtering. Then they read the average CAPEX in the bar chart.

T9: Can you sort out pitches with a total price below 3 Million?

P1 & P2 are able to easily remove the filtering they put on in the T8 and then use the slider filter on the total price. P3 struggled to remove the size filtering before using the slider filtering - and has thus struggled to remove the filtering on all but one task where this is required.

T10: What does the average Capex consist of?

All participants find this task somewhat tricky. P1 found the answer with the help of the text information in the header but did not understand what exactly constitutes CAPEX in the CAPEX table. The other two participants spent considerable time answering the question before P1 finally understood that CAPEX consists of "Disposal cost" + "M2 price" - as the intention with the presentation in the table is. P3 needed a reformulated and more specific question to complete the task and proclaimed that he failed the task due to the wording of the question.

5.2 Results from the post-test questions

Q1: On a scale of 1 to 5, how difficult were the test assignments?

The results from Q1 contribute to which of the dashboards are perceived as intuitive. As shown in the graph, the tasks are considered rather simple, where dashboard 2 is the preference.All participants considered that the user tests were easy to carry out, while they also considered that they were easier to carry out on dashboard 2 than dashboard 1. The given tasks were technically similar, and there was significant reuse of components, e.g. for drop-down lists.

6 We had mock data on different pitch sizes in the user tests to test whether the users handled drop-down filtering.

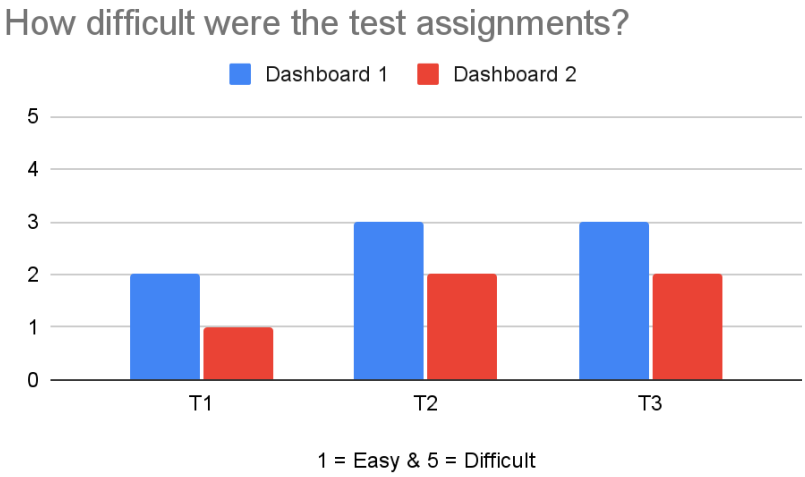

Figure 8- results from Q1

Q2: How would you describe your overall experience with this product?

The purpose of Q2 is to capture the participants' experiences with the dashboard that have not been revealed through the other questions. The feedback shows that the participants prefer dashboard 2.

	Dashboard 1	Dashboard 2
P1	"Would have been a little easier with more explanatory texts"	"Was more explanatory and somewhat clearer than 1"
P2	"Ok, a little more self-explanatory"	"Better compared to dashboard 1. Both dashboards have the information you need for decision making"
P3	"Good overview, use of slightly advanced graphics, numerical basis visible"	"Easy-to-read graphics. Easy to use"

Table 8- results from Q2

Q3: If you could change one thing with this product, what would it be and why?

The feedback shows that both dashboards have potential for improvement, especially with the information texts.

	Dashboard 1	Dashboard 2
P1	"Remove things that may not be completely relevant and more explanatory texts"	"Somewhat more explanatory texts for the various functions, but think this was more clear than 1"
P2	"Simpler visually and more self-explanatory and some more information	"Maybe change something on colour choices, maybe differentiate

	on the screen”	something on the different buttons at the top?”
P3	“Visualise the main components that are part of the main items Capex and Opex (applies to both DB)”	“Smaller text in main image, help text as drop-down menu or bubbles behind question marks”

Table 9- results from Q3

Q4: Assessment of how easy it was to understand that buttons and graphs were interactive elements.

The feedback reports that the interactive elements on both dashboards are somewhat intuitive, with an average rating of 3.

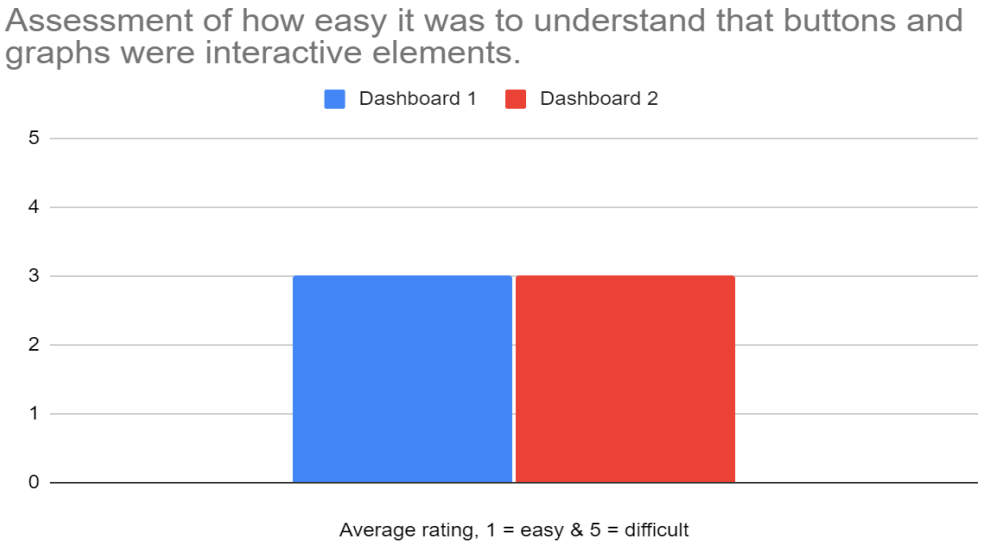

Figure 9- results from Q4

Q5: Which of the dashboards did you find most neat?

Participants find both dashboards neat, with dashboard 2 being preferred.

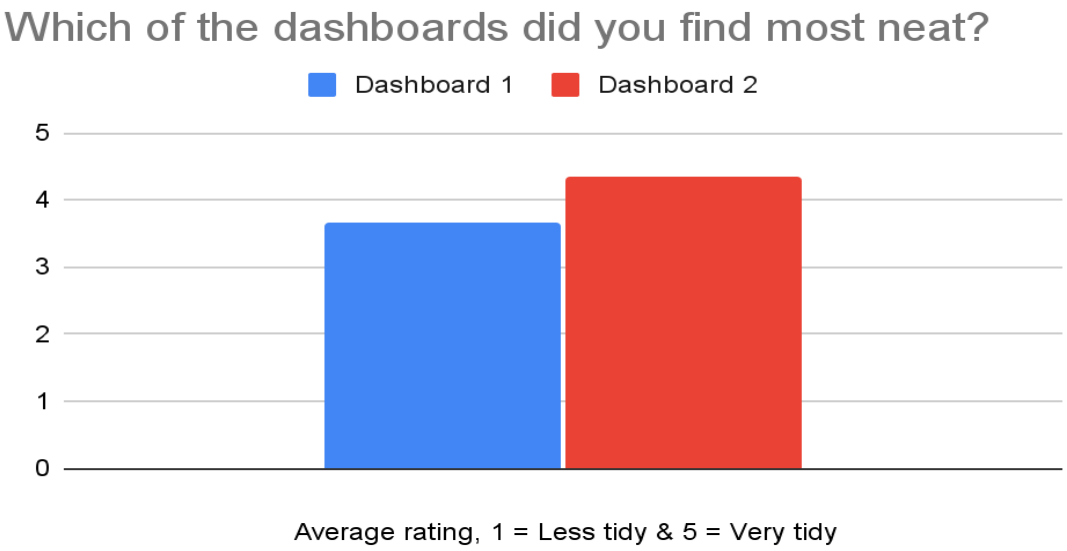

Figure 10- results from Q5

Q6: What was the best and worst thing about the dashboards?

	Dashboard 1	Dashboard 2
P1	"Were some graphs and puzzles in DB 1 I didn't quite understand the purpose of"	"I think 2 had more explanatory information texts"
P2	"a little too easy to fall off, neat and informative when you have worked a bit with reporting"	"Good visually, can work more on differentiating the different filling types"
P3	"Low threshold for use if a short intro is attached. Black background, possibly a bit "Hard"?"	"Good readability. A little too much text outside the model image itself"

Table 10- results from Q6

5.3 Qualitative results regarding the project

Q7: To what degree do you feel you have more knowledge about what the costs of owning an artificial turf consists of?

The feedback is clear that the participants feel they have experienced an increase in competence. We wanted to ask the participants the question to provide an indicator of the contribution the application makes to an objective increase in knowledge.

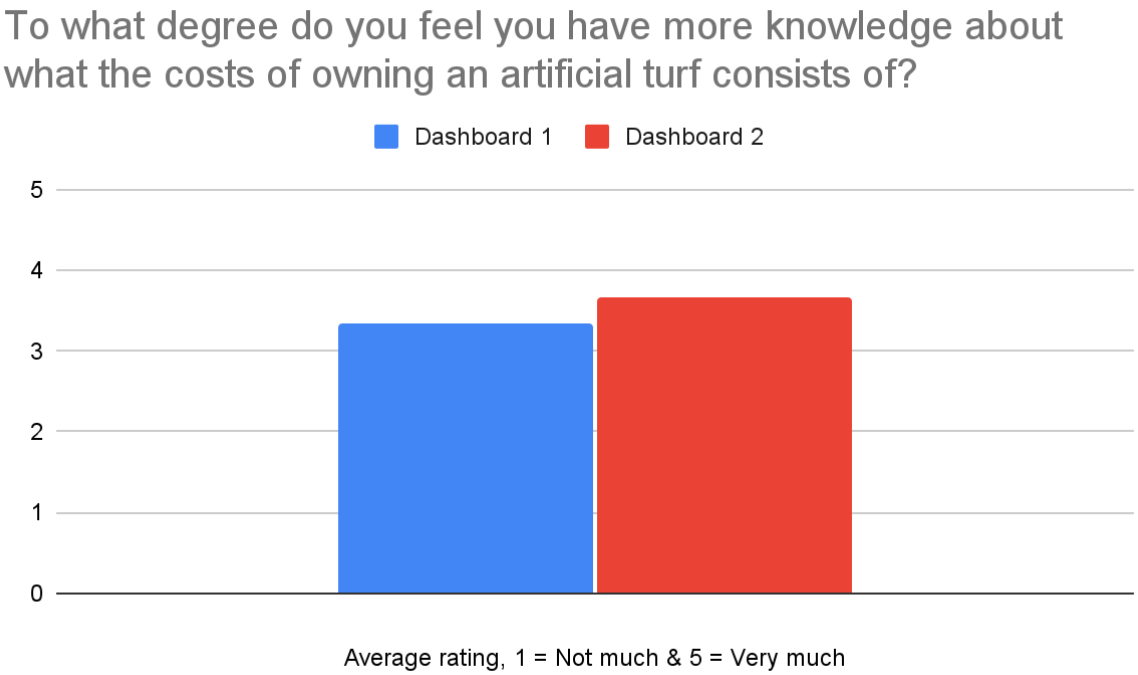

Figure 11- results from Q7

6. Discussion and analysis

The following are the research questions for the discussion and analysis:

- **RQ 1:** Will the tool be accessible?
- **RQ 2:** Will the tool have the usability to support dissemination of KG2021's research?

6.1 User Interface

***Q1:** How difficult were the test assignments?*

It is reasonable to assume that there are several reasons why the participants assessed the tasks on dashboard 2 more easily than on dashboard 1. First, the components are somewhat visually different in design. Dashboard 2, for example, has a greater contrast between the drop-down list and the background than dashboard 1. Furthermore, all interactive components in dashboard 2 have shading, which is typical of such components - and therefore recognisable. In addition, all interactive elements are the same size, something they are not in dashboard 1.

Second, the tests on dashboard 2 were performed after they were performed on dashboard 1. Therefore, one can assume that users were more familiar with how the components worked and how the dashboard was structured and a possible nervousness that had calmed down. On the other hand, there is a weakness with our user testing that we conducted the tests in the order we did, as dashboard 2 had the visual changes to

the components mentioned in the section above. We see that we should have completed the tests first on dashboard 2, then dashboard 1.

Q4: *How easy it was to understand that buttons and graphs were interactive elements?*

Question four deals with the intuition of the user interface and both dashboards were rated equally at 3/5. The dashboards must therefore be said to be intuitive to a certain extent, where both have the potential for improvement. Part of this must be dedicated to Google Materials. Furthermore, it is clear from the user tests that the test persons struggled the most to restore the original condition by filtration, i.e. to reverse the filtration they have used. That may indicate that the users were stressed during the test, as it is essentially the same method of activating and removing filtering for the users. It is particularly plausible to assume this for P1, who struggled to restore the original state of the navigation bar in dashboard 2. He rated the intuition poorly, unlike the other test subjects who rated it averagely.

Q5: *Which of the dashboards did you find most neat?*

Both dashboards are perceived as tidy, where dashboard 2 is rated higher than dashboard 1 by everyone except one test person. Even though dashboard 2 has significantly more elements, texts and generally have less free space. On the other hand, dashboard 2 is built almost symmetrically and has a consistent theme of colour choice and general design. The feedback on why they rated as they did was somewhat divided. Some thought explaining text boxes in dashboard 2 was helpful. Others thought it was too much. One commented that it was not as easy to remove the filters on dashboard 1, although the functionality is relatively the same for both. In addition, a comment pointed out that the purpose of some graphs in dashboard 1 did not come out well enough and that this affected the assessment.

As the feedback suggests, we believe that the answer is complex but are surprised that no one commented on the symmetry and a more implemented theme for the UI. Several studies have concluded that the brain prefers symmetrical shapes (SOURCE), but we have not found a peer-reviewed report that supports this claim. In addition, a comment pointed out that the purpose of some graphs in dashboard 1 did not come out well enough and that this affected the assessment.

The feedback points out that both dashboards were perceived as tidy. Tidiness is something we have emphasised as we found that critical to provide a proper visualisation tool. Combined with the feedback from question 2, regarding their overall experience, do the dashboards visualise information in an appropriate way.

6.2 Availability

The requirements specifications for the application have dealt with accessibility, both for KG2021 and for the users. KG2021 can easily edit the visual content of the dashboard

and integrate it on their website. Users can easily visit the application without the process being more difficult than clicking on a link that led them to it. Furthermore, as mentioned in chapter 3.4.2, the dashboard is universally designed and available on any desired device, at the same time as the results from the user tests indicate that the user experience is good. Our focus on accessibility has been that the threshold for using the application should be minimal. The mentioned threshold naturally affects the change process the target group must go through if the purpose of the application is to be realised.

Both the results and the observation from the user tests made it clear that the participants preferred dashboard 2. In particular, the filtering, and the removal of it, worked via a look-a-like navigation bar instead of a drop-down menu, took less time and is therefore preserved for our end product. On the other hand, Q3 revealed that P1 did not understand the purpose of our treemap, and we consequently removed it.

The medium KG2021 chooses to integrate the dashboard also plays a role. Although it is not our responsibility, it is clear that the solution can and should be shared on several websites, using only 1-2 lines of code. Again, the threshold for the target group should be as low as possible, and it would be proportionate if the application was shared on websites such as godeidrettsanlegg.no - which has much other helpful information intended for the same target group. The security aspect is also taken care of using Google Data Studios' built-in functionality. KG2021 can determine the permission level for each user and, therefore, facilitate that more users can maintain the application and the dataset and its spread.

6.3 The interplay between dissemination of KG2021 and dashboards

The results from the user testing provide a specific background regarding the dashboard's user interface, but it can also be transferred to a bigger context. The last question in the user-testing focused on disseminating artificial turfs, and the response was quite favourable. The average rating for the last question for both dashboards lies between 2,5 and 3, which reflects that the users felt that their competence increased a bit after using the dashboard.

As the problem definition aims to spread KG2021's research through a technical tool, the question is how we can validate this in reality. The results illustrate that the dashboards could be a form of learning arena, because a dashboard helps users spot patterns, trends and correlations more easily (Bradford, 2015). However, the results only speak for three persons, and it is not fully representative compared to all the other stakeholders of KG2021 that were not a part of this thesis.

On the other hand, the project leader informed the students about the football clubs' information gathering process before investing in a new pitch. He said that many football clubs contact the Norwegian Football Association (NFA) for advice, which can be seen as

natural. After researching NFA's websites regarding artificial turf, we could not find any tool that visualises data about turfs' pricing and the costs. Consequently, we imagine our dashboard can contribute to filling this information gap for the stakeholders, as this specific knowledge is not to be found on NFA's websites. Our dashboard could work as a neutral party and information database for the NFA, suppliers and buyers. Instead of buyers or suppliers scanning through several documents or spending hours counselling with the NFA, the dashboard could simplify the process of gathering the correct information.

On the contrary, although more information will be accessible by publicly sharing the solution, we cannot validate in large scale if it will contribute to dissemination, but we can reflect on potential effects. It will probably take some years to measure the exact degree of dissemination. However, to cause attention and awareness regarding the dashboard and the respective research, KG2021 needs to promote and market the technical tool in order to increase the average knowledge among the stakeholders. That might contribute to dissemination.

6.4 Contribution to objective knowledge increasement

Our user-centred development methodology intertwined with DSR has ensured that the development work has focused on what the artefact should make possible - objective knowledge increase. Furthermore, our method has ensured that the application is adapted for its purpose - in that accessibility and user-friendliness are assessed as good through the user tests. Thus, we consider the artefact to be technically capable of acting as a catalyst in disseminating KG2021's research and values.

Furthermore, the visualised content is based on professional knowledge and documentation. The results from dashboard 1 revealed that the users preferred additional information about both the KG2021 and the LCC analyses in addition to only a visualisation of the LCC analyses. The result was seen in connection with the fact that knowledge transmission is easier the greater the trust between the parties, as addressed in Chapter 2.5. The lesson was thus that the content and context presented to the users is also a criterion for increased knowledge increase.

However, if KG2021's intention for the application is to be fulfilled, today's decision-makers must change how they operate today. They need to change to more data-driven decisions, where they have previously dealt with assumptions, suppliers and consultants. Therefore, there is a process change in the way they obtain information. Trust is, again, necessary for the target group to complete this digitalisation process and increase their knowledge. Therefore, KG2021 has a responsibility to unite its value set with the artificial turf market and promote the solution so that one reaches the decision-makers.

Q7: *Do you feel that you have more knowledge about what constitutes the cost of an artificial turf pitch?*

The result of the question showed that the participants experienced increased knowledge acquisition, and to a greater extent on dashboard 2. Therefore, the answers also indicate that the dashboard is a suitable tool for the purpose. The experience we took on to our end product was that information about KG2021 and the LCC analyses are desirable but with moderation, as Q6 revealed. We, therefore, removed a text field, which we replaced with a visualisation of how many LCC analyses for each infill category on which the representation of OPEX, CAPEX, and TOTEX are based. The purpose is for users to understand better how filtering affects the underlying data set and that not all categories are based on the same amount of data.

Finally, it should be mentioned that P1 rated **Q7** the worst score for both dashboards, as he was familiar with KG2021 and the LCC analyses. Therefore, it is a lesson for us to consider, as we should formulate our questions differently to prevent such outliers.

6.5 Qualities with the method

The following paragraphs will show how we ensured quality throughout our qualitative method. Essential terms to highlight are validity and relevance. These terms can help us ask questions about the knowledge's reach and limitation and further problematise if it is about scientific knowledge (Malterud, 2003, p.21).

6.5.1 Internal and external validity

Have we answered the questions we formulated? Other questions surrounding this particular theme are whether our tools and methods are a part of delivering valid answers to our research or not. The internal validity embraces the practice around if the results and the respective analysis answer the problem definition (Malterud, 2003, p.24). By conducting user tests and receiving answers to receive a sufficient data foundation, we aimed to explore the dashboard's total experience of the dashboard. We believe that developing and testing two different dashboards with noticeable differences strengthened our internal validity. Iteration between the different phases also helped us maintain focus and develop a solution founded on the requirements but targeted for the personas. The test persons were not exactly alike as the personas, but that was a plus. Since we received some feedback that we might not expect, we disclosed aspects we did not imagine.

The external validity is about transferability and whether the results could be generalised and transferred to a bigger context (Malterud, 2003, p.25). As a part of our problem definition, is KG2021 a project with a high sustainability focus, and that is worth mentioning. Receiving a dataset with LCC analysis for 38 pitches represents a pretty realistic picture of the artificial turf market today in Norway. KG2021 gathered the dataset, and the different pitches are located in all of Norway. The results display that adequately visualising the dataset fills a necessary gap for information gathering. Even though we only had three test persons, we can argue that the results could be used in a

bigger context. A dashboard is a tool that helps the user gain insight and potential new knowledge and, therefore, might serve the same purpose in other contexts. However, it somewhat affects the external validity that we did not recruit the test persons, as KG2021 did. If we chose the test persons, we could receive potentially more divergent feedback. On the other hand, the answers to the questions were varied, but it was still a consensus that dashboard 2 was the most appropriate.

6.5.2 Relevance

Relevance reflects on what role the research plays in the bigger picture. It is expected that scientific knowledge will bring recognition that can further be used for something (Malterud, 2003, p.22, translated). As assessed in the theory chapter, there is a general acknowledgement that synthetic infill negatively impacts the environment. However, technical tools to highlight the costs regarding artificial turf are, as the *task description* declares, "poorly developed for this sector". The relevance of this project encapsulates the challenge of implementing a greater extent of sustainability into decision processes and hence accelerating a change of processes. A greater focus on sustainability when managing economic decisions can be done in many ways. In this project, providing a dashboard may influence the stakeholders' awareness on the sustainability topic when making decisions.

One can also discuss the frequency of use of the dashboard among the potential users. Will the application be used, and how often? It is difficult to predict how much the application will be used accurately, but it is a broad group of people connected to the KG2021-project, indirectly or directly. We imagine a natural correlation between the more a user uses the dashboard, the higher the chances of dissemination. However, the more *people* that use it can affect the degree of dissemination in general.

6.5.3 Weaknesses with the research method

No method can be seen as perfect and, at the same time, unaffected by a person's bias and motivation. Every method has its own different weaknesses, and these will be addressed in the following paragraphs.

The first weakness of our method is the user-testing that had to take place over Microsoft Teams. User testing demands observation from the researcher's side, but when we only could see the participants' faces and screens through a computer, the overall observation became more limited. We were not able to examine the whole body language. There could also be misleading communication between the participants affected by a bad connection or relevant technical issues. The interpretation of the feelings of the contributors was also tricky because of the digital way of communication.

The questions asked in the post-test scheme were elaborated to try to get an accurate impression of the participants' opinions about the dashboard. For this reason, there has to be mentioned that participants may not necessarily be sincere when answering the questions, and that is something that weakens this method as well. As we took this into account, a part of our appearance was also to talk with them right after the test, as we

then both received their opinions in oral form and on paper. That gave us an overall perspective about that specific participant's meaning.

Another weakness worth mentioning is the number of participants that completed the user tests. We only managed to conduct the tests with three persons, and to gain even more insight and feedback; it would be better to increase the number of participants. For instance, with 5 test persons, could our external validity expand even more, and the data foundation would be further improved.

Observation has a high chance of being unconsciously affected by the researchers' bias (Prasanna, 2022). Even though one will not notice, every person has their perceptions, which can problematize the objectivity of the research

The last weakness is the level of education the test persons had- to what degree are they representative of the expected users. All three of them had higher education, e.g. a university degree. According to the Danish report, which states that most sports leaders have short vocational educations, that was not the case with our test subjects. That might portray an improper picture of how our dashboard was perceived, as our test users have more theoretical education than we can expect from potential future users.

6.6 Evolution of the dashboard

We conducted the user tests on dashboard 1 and dashboard 2, depicted initially in Chapter 5. The results revealed that the users at both dashboards coped well with the functionality. There were clear preferences that the users preferred dashboard 2, which showed more information about both the analyses and KG2021 - at the same time as the UI was perceived as more tidy. However, the feedback on what should be improved was not in unison. We arrived at improvements to the last iteration through targeted questions and tasks, each with its purpose.

The following questions and tasks, in particular, became important in this process:

T10 "What does the average Capex consist of?"
Q2 "How would you describe your overall experience with this product?"
Q3 "If you could change one thing with this product, what would it be and why?"

T10 revealed that users understand the definition of CAPEX, but they did not understand to the same extent how we visualised that CAPEX was made up of several factors. **Q2** revealed that information texts are desirable and that they are more satisfied with the usability of dashboard 2. **Q3**, on the other hand, revealed that P3 - the project manager of KG2021 - thought that the information texts should be improved and not take up so much space in the dashboard. In addition to the fact that P1 thought that there should be more text, at the same time as P2 pointed out that we should differentiate the colour choice of the buttons.

We ended up iterating on a solution similar to what P3 suggested; to hide text information in layers, which was displayed at the touch of a button. It was a good solution, as we both had room for more text-based information about KG2021, the dashboard's structure, and the LCC analyses, and at the same time, we had room for more visualisation by hiding the text. When we read the feedback, we knew that such functionality was initially not possible in Google Data Studio, as there are no interactive buttons outside the charts. We also knew that we could solve the problem by adding an extra page to the dashboard - but as mentioned in 3.6.2, we did not want a dashboard over several pages as it complicates the user interface. The main reason for this is that Google Data Studio's built-in navigation is well hidden in a small, relatively small font size space - so that the user is almost expected to have previous experience with the product.

After much testing, we found we could create interactive text boxes, which we designed to look like buttons, and automatically redirect the user to the next page. We then designed the next page to be almost the same as page 1, except for pop-up text boxes with the requested information, which one could click away and thus be sent back to page 1. The intention is that the user should not notice that one navigates between the pages at all. Furthermore, we designed the "info" button in slightly different colours from the navigation bar. We did the same with the slider filtering to create continuity between the buttons in addition to the "✕ - Lukk" buttons. We thus also fulfilled the wish of P2, who wanted differentiation in colour choices between the buttons.

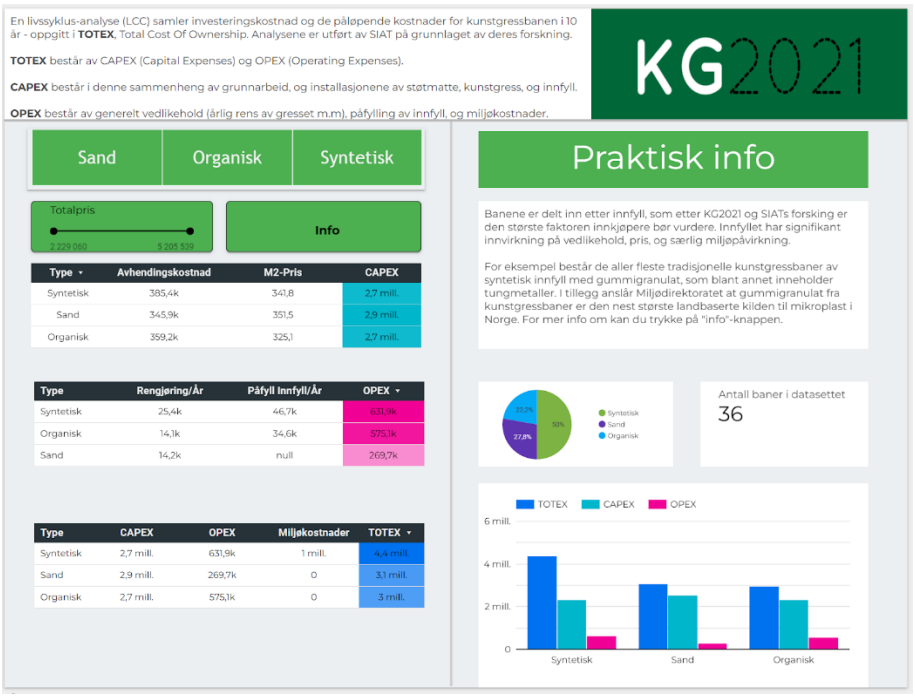

Figure 12- Main page of the dashboard

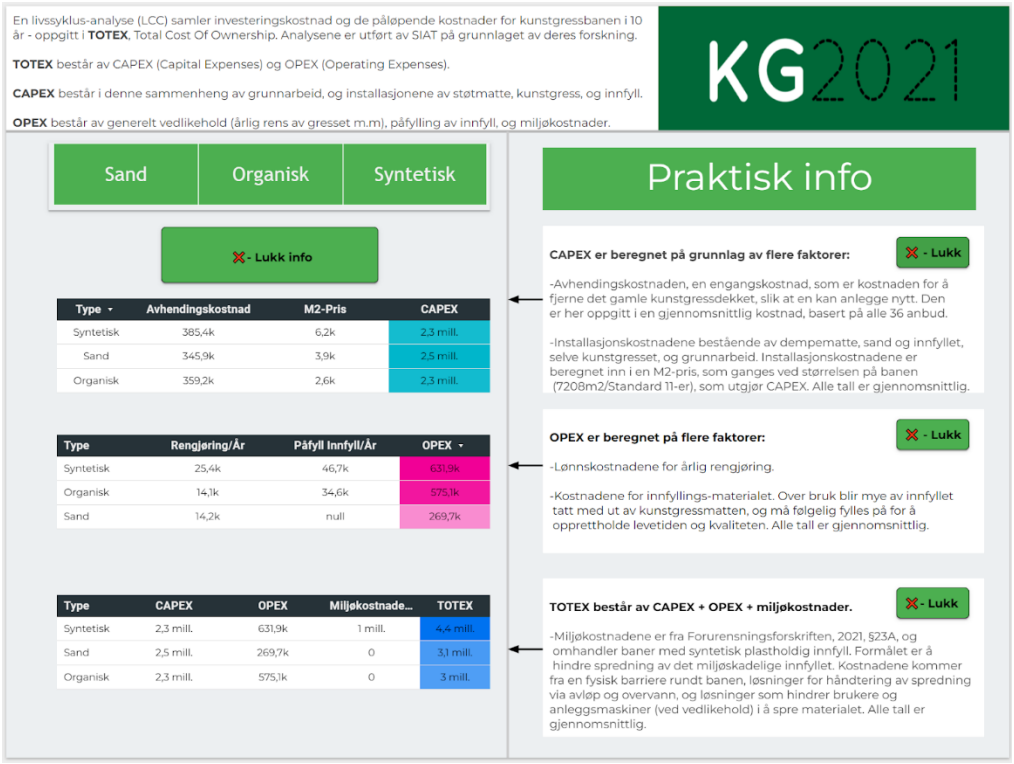

Figure 13- info page of the final dashboard

Each "✕ - Lukk" button has the same functionality, removing the pop-up text boxes, which takes them back to the main page/page 1.

7. Conclusion

7.1 Final conclusion

The application's content is research-based with prepared LCC analyses, where we, in consultation with KG2021, have decided what is most important to emphasise to contribute to knowledge dissemination. Furthermore, there is a significant focus on what kind of technical tools and suppliers have been most suitable for spreading the research, set against the requirements specifications and the framework for both the application and the task. The user testing based on personas has answered that the three-part focus of DSR has been taken care of; relevant to its use, 2) works technically, and 3) based on professional knowledge.

Furthermore, the tests have provided answers to what the users value visually and in terms of content - on which we based our next iteration for the final product. On the other hand, the static basis is too weak to conclude the connection between design principles and preference. The context in which the application was developed has also received much attention. At the request of KG2021, we created an application that will work and be relevant in the foreseeable future, serviced and updated by KG2021 itself. It has been imperative that KG2021 itself can develop the application iteratively in the future if one wishes to redefine the product to meet the users more.

The dashboard can contribute to an objective increase in knowledge and thus more environmentally friendly and financially sustainable future purchases. Users can compare figures themselves and, at the same time, obtain objective text-based information. Whether the application contributes to a changing process with more data-driven decisions for the decision-makers depends a lot on how KG2021 profiles itself and the application.

7.2 Further work

This project has focused on two different aspects: developing and designing a technical tool and being a facilitator for dissemination in light of KG2021 objectives. User statistics is an interesting aspect to consider to increase the dashboard's quality of use and applicability. Obtaining more data about the users and, for instance, where they click could further improve the application in the future. This data could provide an even more nuanced glance of the stakeholders and reflect on whether the dashboard visualises the information in the proper technique.

Another technical aspect that could be improved is the opportunity for the users to add data to the dashboard themselves. By receiving input from the users, realistic bids from suppliers could be compared to the other tenders presented in the solution. Consequently, even more insight and dissemination could occur and thus contributing to KG2021's goals. As mentioned in 3.4.2, this type of functionality is not possible in Google Data Studio, or any of the other free solutions we came across.

Furthermore, we believe that the dashboard can realise its purpose to a greater extent if more relevant data is available. For example, it would probably have been of great help to users to see estimated CO2 emissions for each infill type, where this today is not included in today's dataset. On the other hand, the application is adapted to add both more LCC analyses and other types of data. In addition, KG2021 itself, with Google Data Studio's "drag and drop" interface, can quickly adapt the user interface and the desired diagram.

The dataset provided for this thesis was created in 2019 - 2020. Although the dashboard will be made available in the foreseeable future on KG2021's website, the content depends on being kept relevant to the users. In order to keep the dashboard realistic, the dataset should be updated regularly to serve its initial purpose. If not, the application will likely be outdated in a few years and visualise an older perception of the artificial turf market. In addition, as mentioned, KG2021 itself needs to promote the solution so that actual use takes place.

As of 18.05.2022, the dashboard is not integrated with KG2021's website. However, the clear intention is that KG2021 will complete this. It is straightforward to integrate with the use of iFrame. An HTML iframe is used to display a web page within a web page and is a well-established technology. We tested the integration by setting up a separate website, and it worked without any problems. The dashboard can now be visited via this link: https://datastudio.google.com/s/vjdD2bSxK9U

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9. Attachments

9.1 Personas

These are the personas that were established for this project, in accordance with chapter 2.5 - see section on personas.

Persona number 1:

Field	Explanation
Name	Knut Eriksen
Role	Driving force in the local football club
Demographic information	45 years old. Married and lives in a central city. Is described as well organised, and receives great energy from contributing to sports enjoyment for young people through strategy planning and organisation. Has two teenagers participating in the local sports team. Lives in Fredrikstad.
Knowledge, capabilities and skills	Education at bachelor level within economics and business administration. Has been in a permanent municipal job since graduating, where he works with project planning. After entering working life, he has for just as long cultivated outdoor interests. Otherwise, Knut Eriksen is interested in football, and follows the Premier League.

Goals, motives, worries and considerations	In life in general: · Eriksen wants to achieve more recognition for his initiatives on a professional level. Privately, Eriksen mainly wants to ensure a stable financial future for his family, as well as a core family. · Eriksen is motivated by social recognition and achievement - not only in a professional context but especially linked to his leisure involvement around the sports team. In addition, sports enjoyment is a major motivating factor. · Eriksen is concerned with sustainability. Not only in the economic context, but also for the sports team as a whole and the environment. He therefore often emphasises his actions against the economy and environmental impact. · Eriksen cares little about private well-being, but is more concerned with his professional and leisure progress. How is he placed in the social arena? How is the progress of the sports team? How can one ensure a sustainable commitment for his sons?
Usage pattern	How will the persona use the solution? (Can be several things.) · The solution helps Eriksen to obtain a clear overview of different artificial turf pitches, and what their differences are, so that he can make a well-founded proposal about which solution the sports team should acquire more knowledge about. · The solution saves Eriksen a lot of time, so that he does not have to get into a tangle of different providers with different factual bases. In addition, it is a great advantage that the solution is offered through a neutral party; SIAT. · Eriksen uses the solution relatively only when he wants to get an overview of different types of solutions etc. So relatively little. · Eriksen will focus mostly on LCC functionality, i.e. the TOTEX presentation the solution provides per pitch.

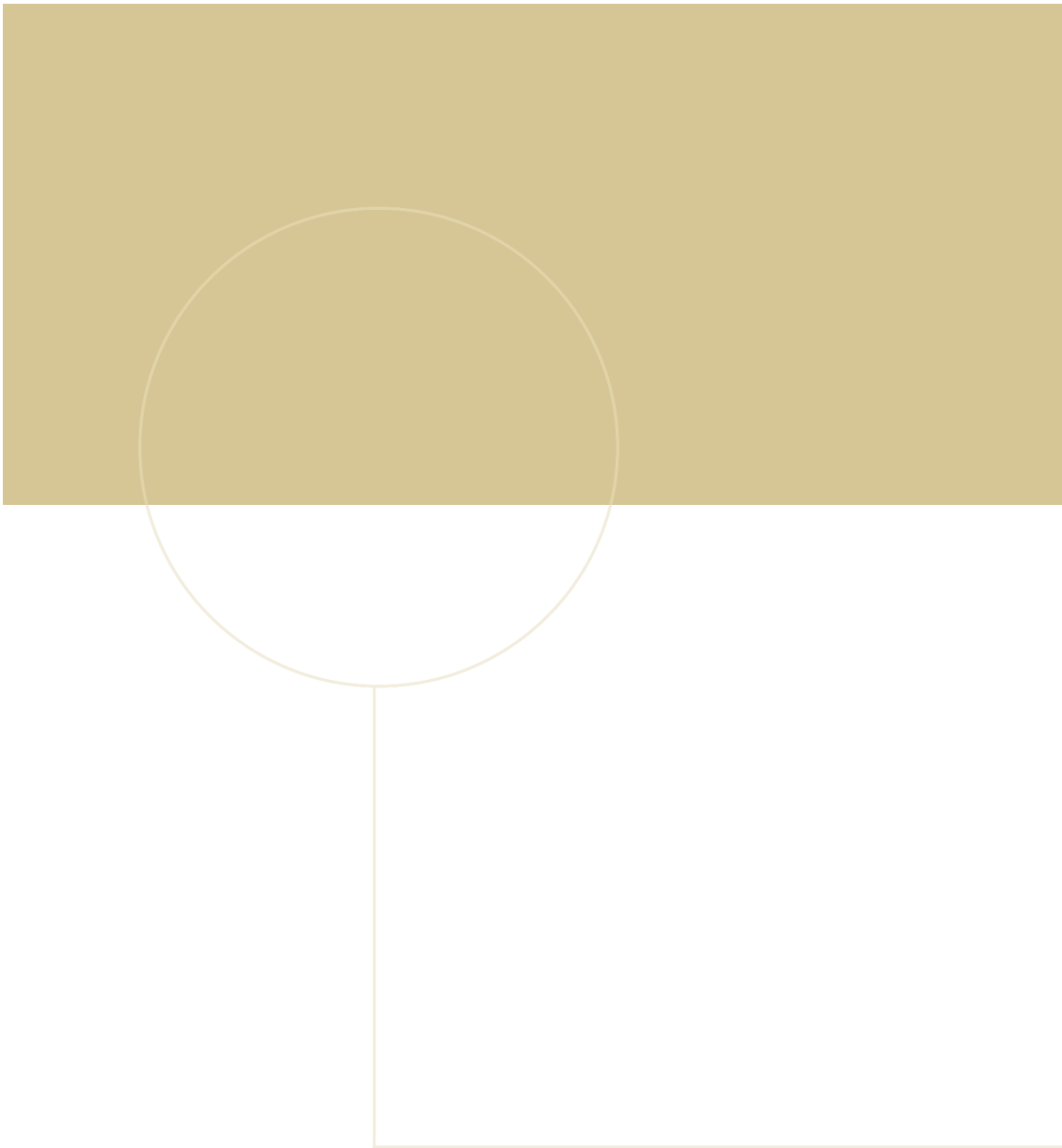
Table 11- persona 1

Persona number 2:

Field	Explanation
Name	Siv Hansen
Role	Representative in the municipal council, with area of responsibility within nature, sports, and leisure. In addition, has several positions in sports, also at the national level.
Demographic information	39 years old. Cohabitant and resident in Drammen municipality. Is described as well organised, and always prepared for meetings. Desired to start a family.
Knowledge, capabilities and skills	Education at bachelor level within economics and business administration. Has worked with party politics since finishing her education, where sports are a priority area. Is competent with technology, and has a good ability to familiarise herself with various operating systems and applications. Sports are otherwise the focus area for the career.
Goals, motives, worries and considerations	In life in general: · Hansen wants to strengthen her political career on a professional level. Has great goals of being nominated by party colleagues for heavier sports policy positions. · Hansen is motivated by achievement, and has clear goals to move larger sports events to Drammen. Working on several projects, where her career reflects the results of her political work. · Hansen is a busy lady. Often reads case documents on the go, and often studies with statistics. Is less concerned with perception, and more concerned that measures should be based on a solid factual basis. · Hansen is concerned about social progress, and is very concerned with networking. An ever-increasing concern is that Drammen is constantly being overtaken by Oslo as a sports city, and that less and less funds are being allocated to sports events and facilities.

Usage pattern	How will the person use the solution? (Can be several things.) · The solution helps Hansen to obtain a clear overview of various tenders, and what is required especially of maintenance after the investment has been completed. Eriksen is well acquainted with the political difference between initial investment and what the total cost after 10 years is. · The solution saves Hansen a lot of time, so that she does not have to get into a tangle of different providers with different factual bases. In addition, it is a great advantage that the solution is offered through a neutral party; SIAT. · Hansen uses the application as a factual basis in discussions, and thus uses the integrity of SIAT. · Eriksen will focus mostly on the environmental aspect of the solution, and is interested in what constitutes the difference between different types of pitches.

Table 12- persona 2



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