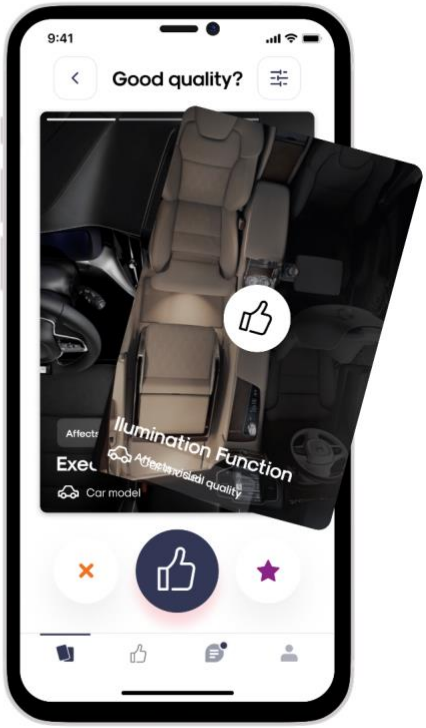
A Digital Gamified UX Solution for Sustainable Quality Attributes Definition in the Automotive Industry



AttributDo

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1 Sammanfattning

Denna förstudie genomfördes som ett samarbete mellan Chalmers tekniska högskola, Göteborgs universitet, Høyskolen Kristiania, Geely Design och China Euro Vehicle Technology (CEVT). Syftet med detta projekt var att identifiera: "Hur kan Quality 4.0-principer och designegenskaper definieras och valideras för ett komplett personbil/fordon?"
Kvalitet har alltid varit en av nyckelfaktorerna för produktens framgång på marknaden, samtidigt som kvalitetskrav är en avgörande insats för design och tillverkning. Industri 4.0 och digital transformation av designprocesserna tillsammans med tillhörande digitala teknologier lovar att göra tidigare subjektiva kvalitetsattribut mätbara i skala som input för design och tillverkning. Här definierar vi Quality 4.0 som "graden till vilken en uppsättning inneboende produktegenskaper uppfyller mätbara krav över alla kvalitetsdimensioner i skala som stöds av digital teknik."
Under den här studien har vi implementerat principer för iterativ deltagande design i stor utsträckning, och introducerat för proffs inom bilindustrin en arbetsmetod baserad på teorin om Gamified Learning. Vi tillämpade spelattribut utanför spelkontexten med syftet att påverka inlärningsrelaterade beteenden relaterade till den väletablerade proceduren för "en komplett fordonsverifiering" inom bilindustrin.

Som det har angetts i målen för denna studie bekräftade vi fördelarna med PQAIR-metoden (Perceived Quality Attributes Importance Ranking) för verifieringsstudierna för designavsikter och identifierade behovet av digitalisering för den specifika uppsättningen av procedurer relaterade till validering av design. attribut. Det så kallade "Severity identification test" studerades och upplevda kvalitetsegenskaper tillsammans med relaterade designegenskaper identifierades.
Dessutom testade och mätte vi målgruppens (bilproffs) UX-upplevelse med prototypen av AttributDo mobilapplikation. AttributDo-mobilapplikationen testades i verkligheten (med hjälp av mobiltelefoner) och levererade olika scenarier för designavsikter enligt PQAIR-metoden med principer för mobilsvepning. Vi upptäckte att detta dramatiskt förbättrade användarupplevelsen.
Genomförbara resultat av detta projekt var två på varandra följande workshops inom ramen för Design Society (www.designsociety.org) och den 23rd International Conference on Engineering Design (ICED), i augusti 2021, Göteborg. Dessa workshops genomfördes av arbetspaketsledare från deltagande universitet men även branschrepresentanter från Geely Design (Sverige) och A2Mac1 (Frankrike). Två vetenskapliga publikationer vi presenterade vid den 54:e CIRP-konferensen om tillverkningssystem (CIRP CMS 2021) i september 2021, Aten. Äntligen genomfördes en datainsamling och analys för den planerade tidskriftspubliceringen 2022.

Äntligen klar, i oktober 2021, genomförde vi en trefaldig workshop i CEVTs lokaler med huvudsyftet att verifiera våra resultat under detta projekt och att få feedback om nästa steg. Fjorton branschfolk - ledande befattningshavare, nyckelpersoner som definierar utveckling och framtida utseende på sina fordon deltog i denna workshop. Vi utvärderade kritiska attributs struktur, verifierade och samlade in feedback för AttributDo-mobilapplikationens UX-flöde, undersökte acceptans av gamification-strategier som ingår i AttributDo.
Sammantaget kunde vi begränsa och identifiera behovet av att fortsätta detta projekt. Resultaten av vår studie tyder på en utveckling och implementering av ett molnbaserat Software as a Service (SaaS) system för en komplett fordonsverifiering avseende intern designavsikt och ytterligare benchmarking bland konkurrenterna. Ett sådant system måste underlätta en repetitiv process av delverifiering med gamification, samtidigt ge bra UX och förmåga att samla in, strukturera och rapportera fynd (olika nackdelar) på skrivbordssystemet via molnbaserade tjänster. Om möjligt måste systemet på mobilapplikationssidan inkludera xR (VR / AR)-element som visar nominell modell för en komponent eller designavsikten, så att utvärderaren omedelbart kan upptäcka och korrekt dokumentera det identifierade problemet. Detta system bör fungera vertikalt - över olika avdelningar som ansvarar för de olika delarna av design och kvalitet (Affärskvalitet, Upplevd kvalitet, Designkvalitet, Geometrikvalitet, Systemverifiering, Ergonomi, etc.). Detta kommer att möjliggöra ett holistiskt tillvägagångssätt för en komplett fordonsverifieringsprocess, som inte bara bidrar positivt till arbetsmiljön, utan ger möjlighet att utföra designanalys retrospektivt vilket möjliggör prediktiva åtgärder inom ramen för Industri 4.0

2 Executive summary in English

This pre-study was executed as a joint effort of Chalmers University of Technology, Gothenburg University, Høyskolen Kristiania, Geely Design and China Euro Vehicle Technology (CEVT). The purpose of this project was to identify: "How can Quality 4.0 principles and design features be defined and validated for a complete vehicle?"

Quality always have been one of the key determiners for the product's success in market, at the same time quality requirements is a critical input for design and manufacturing. Industry 4.0 and digital transformation of the design processes along with its associated digital technologies promise to make formerly subjective quality attributes measurable on scale as input for design and manufacturing. Here we define Quality 4.0 as the "*degree to which a set of inherent product characteristics fulfils measurable requirements across all quality dimensions on scale supported by digital technologies.*"

During this study we widely implemented principles of iterative participatory design, introducing to the automotive industry professionals a working methods based on the Theory of Gamified Learning. We applied game attributes outside the context of a game with the purpose of affecting learning-related behaviors related to the well-established in the automotive industry "a complete vehicle verification" procedure.

As it has been stated in the goals of this study, we confirmed the advantages using the Perceived Quality Attributes Importance Ranking (PQAIR) Methodology for the design intent verification studies and identified the need of digitalization for the specific set of procedures related to validation of design attributes. The so-called "Severity identification test" was studied, and perceived quality attributes along with the related design features were identified. Moreover, we tested and measured target group (automotive professionals) UX experience with the prototype of AttributDo mobile application. The AttributDo mobile application was tested in real life (using mobile phones) settings delivering various scenarios of design intent according to the PQAIR methodology with mobile swiping principles. We found that this dramatically enhanced user experience.

Feasible results of this project were two consecutive workshops in a framework of Design Society (www.designsociety.org) and the 23rd International Conference on Engineering Design (ICED), in August 2021, Gothenburg. These workshops were performed by work packages leaders from participating universities but also industry representatives from Geely Design (Sweden) and A2Mac1 (France). Two scientific publications we presented at the 54th CIRP Conference on Manufacturing Systems (CIRP CMS 2021) in September 2021, Athens. At last, a data-collection and analysis performed for the planned journal publication in 2022. Finally, in October 2021, we performed a three-fold workshop at CEVT premises with the main purpose to verify our findings during this project and to receive feedback about next steps. Fourteen industry professionals - senior management personnel, key people who define development and the future look of their vehicles participated in this workshop. We evaluated critical attributes' structure, verified, and collected feedback for the AttributDo mobile application UX flow, investigated acceptance of gamification strategies included in AttributDo.

Overall, we were able to narrow down and identify the need for the continuation of this project. Outcomes of our study suggest a development and implementation of a cloud-based software-as-a-service (SaaS) system for a complete vehicle verification regarding internal design intent and further benchmarking among the competitors. Such a system must ease a repetitive process of parts verification with the gamification, at the same time providing good UX and ability to collect, structure and reports findings (various demerits) at the desktop system via cloud-based services. If possible, the system on the mobile application side must include xR (VR/AR) elements displaying nominal model of a component or the design intent, so the evaluator can immediately spot and properly document the identified issue. This system should work vertically – across various departments responsible for the different parts of design and quality (Business quality, Perceived quality, Design quality, Geometry quality, System verification, Ergonomics, etc.). This will enable a holistic approach to a complete vehicle verification process, not only positively contributing to the working environment, but providing ability to perform design analysis retrospectively enabling predictive measures in the frame of Industry 4.0

3 Background

The manufacturing industry is transitioning towards a more digital, data-driven future commonly referred to as Industry 4.0 (Thoben et al., 2017; Xu et al, 2018). Under this paradigm, the cyber- and physical-world continue to merge (Lee et al., 2015; Monostori 2014), enabling manufacturing companies to collect and analyze large amounts of user and usage data (Tao et al., 2018). This enables advanced manufacturing processes as well as new methodologies for product design. Better understanding of customer preferences and requirements (backed by real data) will change the way products are designed and manufactured (Kiritsis, 2011; Amit et al, 2020).

Quality continues to be one of the most important differentiators of manufactured products (Roth & Miller, 1992; Phan et al., 2011). It is crucial in consumers' decision-making processes and key predictor of companies' success. Companies such as Toyota, Mercedes, and Volvo distinguish themselves on their product and process quality, terming it a key factor of sustained competitive advantage. The challenge for companies today is to design and produce products with high quality based on given boundaries regarding technologies, development time, production systems capabilities, and financial limitations. Hence, product quality must be controlled during all stages of product development.

Sustainable production is affected by different factors, deeply studied in practice, such as the use of less polluting machines, reducing the generation of un-reusable scraps, and generally reducing waste linked to either economic or environmental issues. Though, while a lot exists to improve the sustainability of manufacturing in that sense, one crucial portion of the product life cycle is often underestimated as enabling sustainable manufacturing: product development.

Automotive mobility and the perception of vehicle design is going through a considerable shift. Two major disruptive trends – electrification and digitalization are changing customer preferences, leading to the probably most substantial transformation in the automotive industry we observed in decades. Finding a balance between customer's requirements towards "zero-emission vehicle," "connected car," choice of materials, clarity of functions, and interface modes under the pressure of production time and cost are not easy.

A design solution often follows what engineers and designers believe the customers should appreciate in the final product. There is no real verification that the features included in the final product are essential for customers. The subjective decisions result in over-engineering, obviously leading to the increased cost of production, harming social and environmental sustainability. The automotive OEMs introduce new quality attributes and design features which supposed to redefine the whole concept of quality perception – Quality 4.0 (e.g., Polestar introduces new innovative interior materials reducing the CO2 footprint; Audi brings a high-end sound for the future electric cars, fulfilling EU requirement for the artificial exterior sound; our research group in Chalmers investigated the subject of vehicle lighting and customer perception together with CEVT (Stylidis et al., 2020).

Previously, we developed and successfully implemented in industrial practice a new methodology for the evaluation of quality impression in the automotive industry (Stylidis, Wickman, and Söderberg, 2020). This publication becomes and continues to be the most read paper in the Journal of Engineering Design (Taylor&Francis) with an increasing number of citations. The Perceived Quality Attributes Importance Ranking (PQAIR) methodology recognized and adopted fully or partially by the majority of global automotive industry players The leading automotive benchmarking company worldwide – A2Mac1 announced a partnership with the Geometry Assurance and Robust Design research group at Chalmers University of Technology and supported scientific publications in a frame of this study (A2Mac1, 2020).

During our studies on car companies, we identified an apparent need to provide a robust solution for ideation, definition, and validation of new quality-related attributes. The Quality 4.0 processes should close the gap between the manufacturer and the customer's perception, therefore, warrant customer perception.

A typical illustrative industrial case on a vehicle verification is the use case evaluating geometry appearance attributes, exemplifies existing boundaries between design, manufacturing, and perceived quality (PQ). A car's performance is determined by a variety of product attributes, including PQ as an important attribute associated with overall car quality that conflicts at times

with measurable quality characteristics. The quality of a vehicle's optics is defined by the Appearance Attributes (AA), including subareas such as interior, exterior, and Day Light Opening (DLO). Each area is evaluated independently by associated AA. The AA can be mapped to the Ground Attributes of the Perceived Quality Framework. The values assigned to each attribute are based on the subjective evaluator's judgement. For example, spot welding is probably one of the most dominant methods for joining sheet metal in the automotive industry. Spot weld quality is a critical factor of the vehicle performance characteristics, such as stiffness and crash behavior. While manufacturing control for spot welding is well established, the verification methods for the perceived quality and appearance prediction are largely absent.

As a result, a majority of car manufacturers hide outcomes of the manufacturing processes as non-compliable to the 'good' visual quality of a vehicle. The current practice of product quality, with manufacturing quality separated from perceived quality, leads to an inflexible process of defining meaningful customer requirements. Examples include traces of machine that are impossible to evaluate objectively as well as the tooling taint line in plastic moulding.

Figure 1. Spot weld position without (left) & with (right) perceived quality consideration

The principal definition of quality did not change over time, however, the domain- and industry-specific practice adapted the general paradigm based on their unique requirement and (technological) barriers. Available technological and economic means did not allow to collect, curate, and analyze data to measure, quantify, and predict quality on scale. However, today quality can not only be determined by human users but also by machines. Hence, it is now possible to evaluate and verify quality applying digital technologies.

The AttributDo-project aims to help engineers and designer to create, define, verify and validate new and existing design features included in the new product development solutions. Gamification have showed to be effective to engaged users in different context, create habits and change behavior (Koivisto & Hamari, 2019) fighting an individual's biases and prejudice (Basol et al., 2020). With the development of AttributDo project, a subtle gamified UX application, we are aiming to answer this call, initially addressing the automotive industry and later with the possibility to generalize results and implement in other industrial domains.

4 Syfte, forskningsfrågor och metod

Two major disruptive trends – electrification and digitalization are changing customer preferences, leading to the probably most substantial transformation in the automotive industry we observed in decades. Finding a balance between customer's requirements towards "zero-emission vehicle," "connected car," choice of materials, clarity of functions, and interface modes under the pressure of production time and cost are not easy. The AttributDo-project aims to help engineers create,

define, verify, and validate new and existing design features for new product development. The main research question we want to answer is “How can new and existing design attributes be defined and validated for a complete vehicle?” The AttributDo intended to help establishing a robust verification methodology for new, undefined today, quality attributes but also for the existing attributes. Successful communication of these attributes can be achieved only with the ability to manage the perception of quality throughout the production cycles. The use of gamification as a means of learning from customer feedback makes for a more sustainable design process. AttributDo reflects real-world situations and magnifies the important details.

In the scheme of the **WP1** we framed a product attributes space included into AttributDo application as a reflection of the internal verification processes in CEVT and Geely Design. Here we applied design research in the form of an exploratory case study, including case design and data collection techniques (Yin, 2013). The information was gathered through different channels. A set of unstructured conversational interviews, together with informal conversations served as the main source of information together with the feedback we gathered during workshops. The relative easiness of the WP1 performance related to the previous work we performed with both companies and their familiarity with the PQAIR methodology. The major outcome for the WP1 was the definition of vehicle’s areas for assessment in the framework of PQAIR and its Ground attributes. This product scheme will reflect actual needs and problems of the automotive industry regarding quality impression and design.

In **WP2** a mixed-method approach was employed, emphasizing design science research (DSR) (Hevner et al. 2004), design science research methodology (DSRM) (Peffers et al., 2007/2012) and Design Ethnography (Crabtree et al., 2012), particularly participatory design (Baskerville & Myers, 2015) with the different stakeholders in the project. The systematized design and development process in DSR leads to better resource allocation, indeed when relying on the design science research methodology (DSRM), which employs six linked sequences in its design process with four underlying entry points for the researcher to pursue (Peffers et al., 2012). These six linked sequences, safety criteria, make DSR ideal for minor projects with limited resources than other design processes such as action design research. Applying the DSR approach required the project group to scrutinize previous research on how to conduct a prolific gamification design within the scope of our project (see Table 1) and commence dialog with relevant stakeholder groups (various personnel from CEVT, independent industry designers, scholars with a design focus) to estimate the contemporary situation and determine the more specific predicament and how the designed tool should be outlined to best address the affirmed predicament. The gamification framework came to consist of equal parts of previous research and information gathered through stakeholder interaction. WP2 focused on quandary ascertainment by surveying the field through reviewing previous research on designing gamification (see result) and interviewing diverse stakeholder groups, analyzing their conditions, and with that information generating personas. The constructed personas came to constitute the conceptual framework of the gamification artefact.

The **WP3** focused on iterative participatory design, by doing workshops with various stakeholders collecting an ethnographic design record. The purpose of the ethnographic record was twofold: collecting diverse data to inform the later design and development, likewise, triangulating and justifying the investigation conclusions. The initial stakeholder design workshops were conducted at the ICED conferences focusing on design scholars and industrial designers attending. We gave two half-day workshops during the conference focusing on product useability, sustainability, playability, innovation as well as users' technology acceptance and adoption.

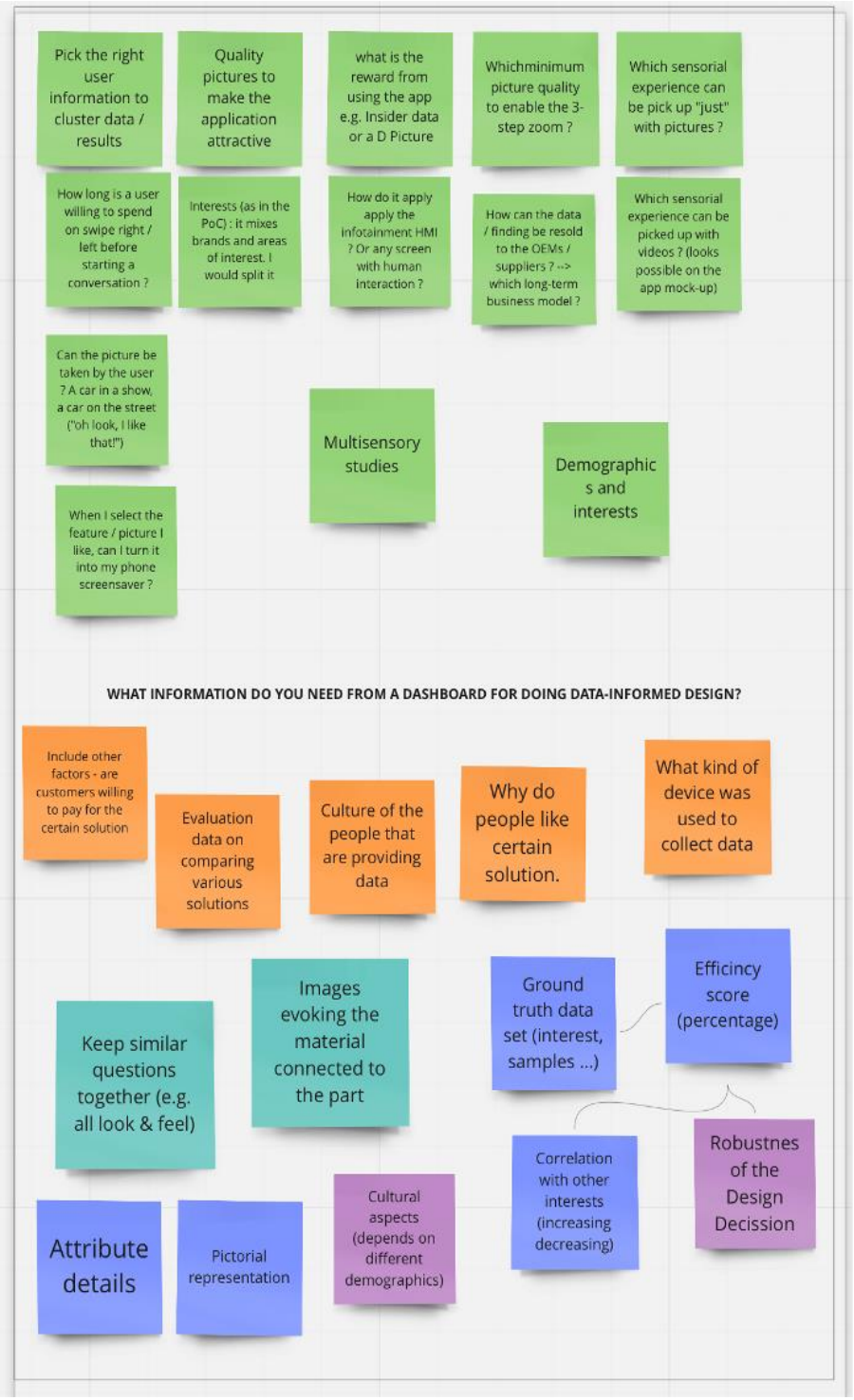

Figure 2 Part of the Ethnographic record from ICED stakeholder workshop

The second cluster of stakeholder workshops was conducted at CEVT, focusing on different stakeholders operating within a perceived quality value chain. The workshops CEVT addressed stakeholder interdependencies to identify feasible value (co)-creation confluences that could inform and later be used in the artefact outline.

Finally, in the frame of **WP4** we performed content analysis of the collected data, verified our findings with industrial stakeholder pointing out the need of further development. The research group also engaged in the process of writing a journal article on the data we collected.

Figure 3 Stakeholder interdependencies

5 Mål

The main research question we wanted to answer is “How can new and existing design attributes be defined and validated for a complete vehicle?” The AttributDo intended to help in verification of new, undefined today, quality attributes. Successful communication of these attributes can be achieved only with the ability to manage the perception of quality throughout the production cycles. The use of gamification as a means of learning from customer feedback makes for a more sustainable design process. AttributDo reflects real-world situations and magnifies the important details.

The project consisted of four work packages (WPs) where WP1 a definition of design intent at Geely Design and CEVT, including identification of the critical product quality attributes for the complete vehicle, specific component or vehicle’s area. The WP2 focused on the needs finding from Geely Design and CEVT. The WP3 involved the design and development of the AttributDo. Finally, all results from the project are validated and disseminated in WP4.

Our primary goals during this project have not been changed. We tested gamification strategies, usability approaches and gathered rich target group (engineers) data. However, it’s become clear that before we even start definition of new design attributes, the direct need for both companies (CEVT and Geely Design) is a robust, repeatable and quantifiable complete vehicle attributes verification system. Automotive professionals require Software-as-a-Service (SaaS) cloud-based system to perform and report a complete vehicle verification task. Therefore, today we see AttributDo mobile application design just as a part of a larger system that we hope to address in the continuation of this call.

6 Resultat och måluppfyllelse

The AttributDo application was designed by game-based learning researchers with the assistance of researchers and professionals of the automotive industry. The results are both research-oriented as well as industry-focused. During the project, the different stages in the development will be documented. This data has been used to write conference papers, journal papers, and chapters in the field of game study, sustainability, and engineering. The involved universities verified the AttributDo app early prototype by organizing workshops together with Geely Design and CEVT.

All in all, we conducted 12 variated participatory design workshops with the purpose to inform the artefact design, chart critical stakeholders as well as identifying current enablers and barriers for the product. The projects´ ethnographic record consists of audio-visual recordings, photographs, transcripts, wire-frames, mock-ups, flowcharts, mind maps and other workshop artefacts from the diverse contexts reviewed – a corpus of data that both refines and visualizes the potential advancements for the project. Also, several learnings from tests are applied in the high-fidelity gamification design described in the figures (Fig 4 and 5) below.

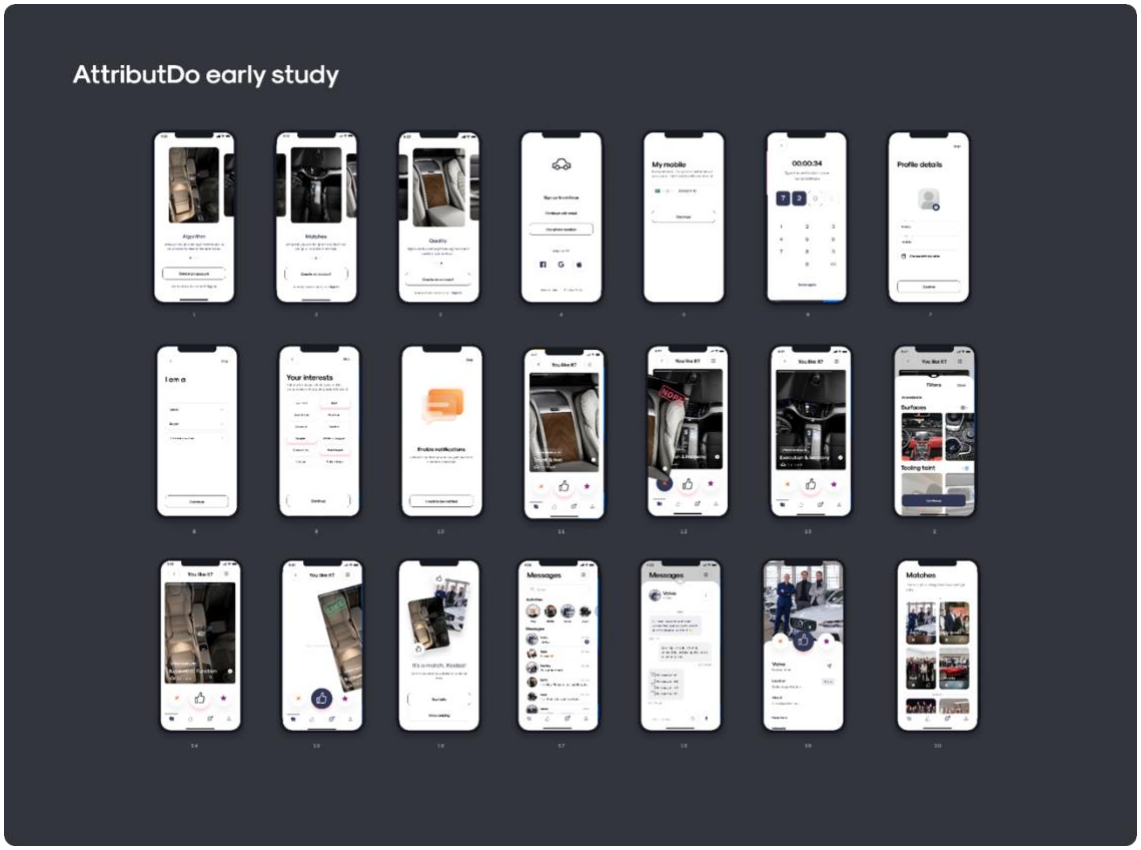

Figure 4 AttributDo early prototype

Included in the results are the list of gamification design frameworks. In the WP2 report on gamification design frameworks, we have used a synthesis rationale based on Mora et al. (2017), Morschheuser *et al. (2018)*, Shahari et al. (2019) typologies due to their similarities regarding the design phases as well as sequences in DSR. To avoid confusion with the original articles outlined phases, we renamed the phases to similar categories: Shaping, Accumulating, Comprehending, Designing Implementing, Evaluating and Monitoring. We also added the category *Addressed stakeholders* for the project purpose. 2 of the 31 articles discuss gamification project from a stakeholder-like perspective, which was significantly lower than expected.

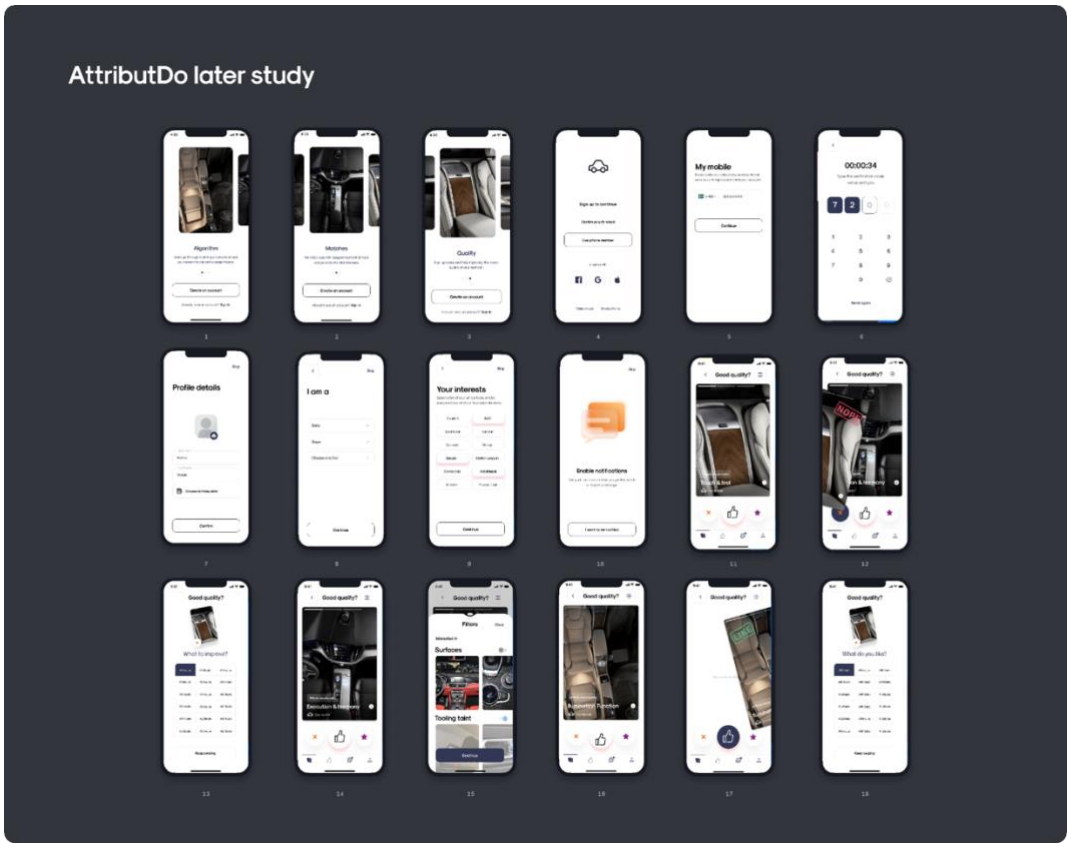

Figure 5 AttributDo later prototype

Table 1 – Research overview on prolific gamification design

Framework	Phases							Context	Addressedstakeholder
	Shaping	Accumulating	Comprehending	Designing	Implementing	Evaluating	Monitoring		
Ana et al. (2016)	✓	-	✓		-	✓	-	Education	Students
Brito, Vieira & Duran 2015	✓	✓	-	✓	✓	✓	-	IS	End-users
Burke 2014	✓	✓	✓		-	✓	✓	HCI	End-users
Chou, 2013	✓	-	✓	✓	-	-	✓	Business	End-users
Deterding 2015	✓	✓	✓		✓	✓	-	HCI	End-users

Dignan 2011	✓	✓	✓		-			Marketing	Customers
Fitz-Walter 2015	✓		✓		-	✓		HCI	End-users
Francisco-Aparicio et al 2013	✓	✓	✓			✓	-	IS	End-users
Helms et al. 2015	✓		✓		✓	✓		IS	Learners
Hereger 2014	✓	✓	✓	✓	✓	✓	✓	IS	Customers
Herzig et al. 2015	✓	✓	✓		✓	✓		IS	End-user/ gamification-domain-business- and IT-experts
Jiménez 2013	✓		-	✓	-	-	✓	Universal	End-users
Kapp 2012	✓	✓	✓		✓	✓	-	Education	Students
Kappen & Nacke 2013	✓			✓	-	✓	✓	HCI	End-users
Klevers et al 2015	✓		✓			✓		IS	Employees
Klock et al. (2019)	✓	✓	-	✓	-	-	-	Education	Students
Kotini & Tzelepi (2015)	✓	✓	✓		-	✓	-	Education	Students
Kumar & Hereger 2013	✓	✓	✓		-	✓		Interaction Design	Employees

Marche-Francico & Branger 2013	✓	✓	✓		-	-	-	Software Engineering	End-users
Mora et al. (2015)	✓		✓		-	✓	-	Education	Students
Nicholson, 2015	✓	-	✓	✓	-	-	-	Education	Students
Paharia 2013	✓	-	-	✓	-	-	✓	Marketing/Business	End-users
Radoff 2011	✓	✓	✓		-	✓	-	Business	End-users
Robson et al 2015	-	✓	✓		-	✓	-	Marketing	Designers/ Players/ Spectators/ Observers
Sheldon, 2012	✓		✓	✓	-	-	-	Education	Students
Simões et al 2012	✓	-	-	✓	-		-	Education	Students
Toda, et al 2019	✓	✓	-	✓	-	✓	-	Education	Students
Tondello et al.2016	✓	✓	✓	✓	-	-	-	HCI	End-users
Werbach & Hunter 2012	✓	✓	✓		✓	✓	-	Business	End-users
Wongso et al 2014	✓	✓	-	✓	-	✓	-	Education	Students
Zichermann & Cunningham 2011	✓	-	-	✓	-	-	✓	Business	End-users

AttributDo – Data Informed Design Prototype

Introduction

UX design uses research data of various kinds to determine how to provide an optimal user experience. The data helps product teams understand their target users, reveals information about users' pain points, unearths new trends, and supports data-driven design. This part discusses the process of making and exhibiting the first prototype (Fig 4) of our data informed design app called AttributDo, at a CEVT / Geely Design workshop using a swipe card interaction like dating apps for quick a/b testing and the potential to connect with design teams and/or quickly select demerits for automotive improvements.

Simplifying the Prototype

The simplification process of the prototype was carried out in the CEVT / Geely Design workshop, where we simplified the prototype (Fig 5) to just the swipe card interaction and the ability to select the demerits.

The Qualitative Usability Testing (UT)

We conducted a qualitative usability study of a simplified AttributDo using the PQAIR framework through the following steps and the participants were asked the questions associated to each step.

STEP 1: Swipe the interactive cards by choosing "like" (right swipe)
Question 1: What do you think of the process of swiping the quality attributes?

STEP 2: Choose not to "like" the quality attribute (left swipe)
Question 2: What do you think of the process of tagging demerits and then choose a Likert scale?

STEP 3: Choose "Keep swiping" and go through the same steps again
Question 3: What other additional features would you like see?

The user testing of 5 minutes was followed by 5 minutes discussion.

Inferences from Participants' Discussion

Out of all the (n=14) participants, the 04 were the Perceived Quality Attribute Leaders, 03 belonged to Quality Validation, 03 were Design Engineers, 01 was Geometry Engineer, 01 was Verification Complete Manager and 01 was an Ergonomics Attribute Leader.

The most used keywords extracted from the moderated UT interviews are: Swipe, Interface, Tagging, Issue, Testing, Quality, Merits and Cost.

Some of the participants' feedbacks and results inferred from them are:

- Just swiping is easy to use, it's user friendly and efficient.
- The processes of tagging the merits to improve attributes help to make rating.
- Tagging the merits and then choose a Likert scale, to improve attribute is a useful feature.
- The issue tracking system requires some data, like the weather condition.

- A good quality is not just the demerits, but also the strength. If you're trying to understand your product strengths or what people like about your product, then the question for positive like what you like about this, can help.
- If you want to understand your brand or your product better, you must find issues and try to solve them, then it will work too.
- It is better use an interface like a touch, like a phone. People are used to this kind of interface swiping right and left.
- It will be good to have some sort of text, like your comments.
- More people are getting more and more into swiping. It is a fast way of working you work with the app.
- A demerit description explaining the nuts and bolts of the in-focus attribute.
- Choosing demerits for liked attributes as well as the not liked ones.
- The need for “keep swiping” need to be improved as suggested by few participants.

We could summarize as follows:

- Swiping right and left makes a good quality design and could improve both the effectiveness and user-engagement.
- We have emphasized on the qualitative data in our app design—This is the data that demonstrates why and how. Why does a certain group of participants take one action, while others choose another? Why does one piece of content keep them on the app longer than another? Qualitative data offers perspective and helps us understand not just what happened, but why and how it happened.

UX Research Methods for Useful Data Delivery in Future AttributDo Versions

While developing the prototype, we knew that with good data, you can create a better user experience and influence user behavior more effectively.

Data-driven design uses UX research methods such as surveys, usability testing, behavior flows, tracking analytics on web sites or in mobile apps, competitor analysis, and heuristic evaluations.

In the coming versions of the AttributDo prototype we intend to incorporate benchmarking tools and design analytics that will make it simple to see how your data is doing in comparison to the industry average.

- **Continuous Usability Testing**

Our designers are not our users. Automotive user-groups come from different demographics and perspectives. Both navigate technology differently and have different expectations. Fortunately, designers can bridge the gap with UX research—especially generative user research and usability testing.

Usability testing lets us evaluate how easy a design solution is to use. We will continue to conduct usability testing either in a lab or in-the-wild at various stages of the software-development process. Generally, we gather qualitative data about participants’ experience with a product, but we could also collect some quantitative data as the prototype supports such functionality.

- **A/B and Longitudinal Testing**

A/B and multivariate testing let us see how different versions of an app perform against one another. We can use these approaches to make big improvements to our user experience and drive user behaviors as well. Continuously running A/B tests to improve a design can result in huge increases in conversions.

- **Behavior Flows**

Behavior flows can also show how users traverse an application—from the first swiping page to the last page they view before exiting the app. In most cases, there is a certain path that UX designers would prefer that users take through an app. If the actual behavior flows differ greatly from that path, there may be a problem with the user experience.

However, figuring out surface-level patterns isn't always indicative of an issue. Perhaps participants abandon the app on one particular page because they've completed their task, but we won't know for sure until we look at the data more deeply—especially where there are anomalies in the data. Balancing the quantitative and the qualitative data is where our core ambition comes into play.

Gamification Design Framework

Plotting our collected theoretical, gamification design frameworks, and empirical, ethnographic record, data using the gamification motivational affordances outlined by (Koivisto & Hamari, 2019), we suggest that the following affordances could be of interest for the first iteration of the artefact design Table 2.

Motivational Affordance	Group	Design outlook
Collaboration/ Peer-rating	Social	A peer feedback feature for incentivizing a more accurate as well as inviting quality inspection
Progress bar/Performance stats	Achievement/Progression	A visualization feature displaying progression as well as performance which gently indicate subsequent quality inspection task.
Game rounds	Miscellaneous	Distinct sequences provided in the quality inspection that indicate a clear start and a stop.

A potential description of the upcoming gamification is a collaborative multiplayer experience elevating quality inspection performance and progress in a sequenced, preferably digital, artefact. For the future design and development process, a recommendation is a constricted participatory design process with the key stakeholders directly interdependent of altering the current quality inspection process. Together with these stakeholders, various diminutive designs should be examined in a design iteration cycle to crystallize the most suitable outline of the impending quality inspection artefact.

7 Spridning och publicering

7.1 Kunskaps- och resultatspridning

Hur har/planeras projektresultatet att användas och spridas?	Markera med X	Kommentar
Öka kunskapen inom området	x	Kombinationen av avancerade UX-praxis med gamification-strategier som tillämpas på den specifika industriella uppgiften är ganska unik.
Föras vidare till andra avancerade tekniska utvecklingsprojekt	x	Vi planerar att söka till steg två
Föras vidare till produktutvecklingsprojekt	x	Pågående
Introduceras på marknaden		Nej
Användas i utredningar/regelverk/ tillståndsärenden/ politiska beslut		Ingen

7.2 Publikationer

Stylidis, K., Rossi, M., Žukas, J., & Söderberg, R. (Nov 2021). **Addressing information asymmetry during design: customer-centric approach to harmonization of car body split-lines**. Procedia CIRP, 104, 110-115.

Quattelbaum, B., Stylidis, K., Braun, A., & Söderberg, R. (Nov 2021). **Preliminary study on perceived comfort of car seats: A quantitative approach to visual cues**. Procedia CIRP, 104, 116-121.

In the process:
Stylidis, K., Quattelbaum, B., Rossi, M., Wuest, T., Wickman, C., & Söderberg, R. (ca. 2022)
Impact of electrification trends on the perception of interior design in the EU premium car market segment.
Journal of Engineering Design

Goethe, O., Stylidis, K., Palmquist, A., Bersjö, D., Braun, A., Heimerrson, E., & Siljefalk, L. (ca 2022)
Oh Attributes! An Improved Usability Pipeline to Connect the PQAIR Framework Through Design.
The ACM CHI Conference on Human Factors in Computing Systems is the premier international conference of Human-Computer Interaction (HCI)

8 Slutsatser och fortsatt forskning

Industry 4.0 is associated with a myriad of technologies guiding industry's digital transformation (Mittal et al., 2019). During this study we have identified how to link PQAIR methodology (sensory approach), with seamless user experience powered by the gamification approach to solve a specific industrial demand (a complete vehicle verification). According to Krippendorff (2005): "Humans do not see and act on the physical qualities of things, but on what they mean to them." However, due to human evolution, the focus on the perceptible stimuli has changed immensely. Not only the number of different stimuli in everyday life increased, but also the degree of assessment of urgent and irrelevant information. (Younas M. et al., 2018). The visual, haptic, and sound assessment of the vehicle is one of the early and critical aspects for quality perception, including materials quality, geometry assurance, illumination, and lightning issues. The AttributDo application will help engineers to perform this non-trivial task bringing more objectivity into their final decisions. We were able to identify the exact needs of the engineering teams from various departments responsible for look, functionality, and performance of future vehicles
We are planning to continue this work developing an automated complete vehicle verification system, with the use of xR (VR/AR) technologies representing a nominal model of a vehicle (or part of it) in comparison with the non-nominal vehicle for assessment.

9 Deltagande parter och kontaktpersoner

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