GLASSIFIED

TEAM GLASSIFIED

The Glass ID

iPDP – International Product Development Project

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The Glass ID		Abstract
Team	Glassified	Year 2023
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This project aimed to develop a sustainable alternative to plastic everyday objects by replacing them with glass. Several prototypes were considered. The glass ID card emerged as the primary solution, offering durability, security, and personalized customization options. Challenges were faced during the prototyping phase, particularly with the handling of the sponsor's unique glass material. However, through collaboration, problem-solving and design thinking, these challenges were overcome. The glass ID card proved to be a sustainable alternative to plastic, reducing environmental impact and incorporating advanced security features. This project demonstrates the potential of glass as an eco-friendly option for everyday items, contributing to the reduction of plastic waste and promoting sustainable practices while also highlighting the advantages and disadvantages of recycling. Further development is required to optimize glass-based solutions for mass production and widespread adoption.

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Table of contents

1 Introduction

In a world where the environmental impact of plastic waste is becoming increasingly evident, the search for sustainable alternatives to plastic has become an urgent task. This project aimed to find a solution to this problem by replacing conventional everyday objects made of plastic with more environmentally friendly glass.

Within the project, various ideas and prototypes were developed and evaluated to explore the possibilities and challenges of using glass. Aspects such as durability, safety, aesthetic design, and functionality were taken into consideration.

The prototyping phase was crucial in testing the feasibility and effectiveness of the glass alternatives. Challenges were encountered, particularly in terms of handling and the specific glass material. However, through collaboration, creative problem-solving, and continuous improvements, these obstacles were overcome.

The result of this project is a promising sustainable solution: the development of everyday objects made of glass, which provide a more environmentally friendly alternative to conventional plastic. These solutions contribute to the reduction of plastic waste, the protection of the environment, and the promotion of sustainable lifestyles.

This project underscores the importance of innovation, research, and collaboration in developing sustainable alternatives and reducing the environmental burden of plastic. It represents a step towards a more responsible and eco-friendly future.

1.1 Our Team

The International Product Development Project (iPDP) brought together a diverse team of five individuals, each with unique backgrounds and expertise, to collaborate on a challenging and innovative project that is a part of Attract. This introduction aims to provide an overview of the team composition, emphasizing the strengths and diversity that each member brings to the project.

With a range of backgrounds and experiences, we represented various disciplines and cultures, fostering a rich environment for idea generation and problem-solving. Our team consisted of individuals from different academic backgrounds such as chemical engineering, design, business, and computer science, creating a dynamic blend of technical knowledge, creative thinking, and strategic acumen.

The team members possessed a wealth of practical experience in their respective fields, which further enriched our collective capabilities. Some team members had prior experience in product development and design thinking, bringing valuable insights into the project's lifecycle and best practices. Others had experience in IT and engineering, enabling us to navigate difficult and complicated task with ease.

Moreover, our team was characterized by a shared passion for innovation and a drive to excel in the iPDP/Attract project. Each member brought a unique perspective and set of skills, fostering a collaborative environment where diverse ideas were encouraged and respected. This diversity allowed us to approach challenges from multiple angles, stimulating creativity and promoting comprehensive problem-solving. Our team consisted of Patrik Koptik and Christian Nitsch who are both studying bachelor's of computer science at the university for applied science of Mannheim in Germany, they are joined by their School-mate Markus Fauss who studies Chemical Engineering at the master's level. As for the Finnish side, Alexandra Pennanen-Kok and Lucia Anna Franková are bachelor students of Smart and Sustainable Design, in the field of Glass.

Effective communication and teamwork were key pillars of our success as a team. We established open lines of communication, creating a supportive and inclusive atmosphere that fostered collaboration and idea sharing. Such as the idea for us to create our team name, team Glassified. Regular team meetings and virtual platforms facilitated seamless information exchange and decision-making processes. The ability to effectively communicate and understand each other's perspectives was crucial in achieving our project goals.

As a team, we recognized the significance of the iPDP experience and the opportunities it presented for personal and professional growth. We embraced the challenge of working in an international and multi-disciplinary team, viewing it as an opportunity to broaden our horizons, develop cultural intelligence, and expand our networks.

Throughout this report, the accomplishments, challenges, and collaborative efforts of our team will be highlighted, offering insights into the dynamics and effectiveness of our Glassified team. The subsequent sections will delve into the specific project details, lessons learned, and the impact of our collective efforts.

Overall, our team's composition, diverse expertise, and commitment to collaboration laid the foundation for a successful iPDP experience. Through effective communication, shared goals, and mutual respect, we aimed to achieve remarkable outcomes and leave a lasting impact within the realm of international product development.

1.2 The Challenge

In the International Product Development Project (iPDP) assigned to our team, we had the privilege of working with Glassomer, an innovative company that has revolutionized the production of high-precision glass parts. Glassomer has developed a unique, patented process for creating composite materials that can be shaped like polymers and subsequently transformed into fully transparent fused silica glass. Their groundbreaking technology enables the 3D printing of glass, opening up new possibilities in the realm of manufacturing and design.

Our task was to conceptualize and develop a product that would leverage Glassomer's 3D printing or injection molding technology. This product could be sold through their existing shop or contribute to their future vision. Our team was aware of the immense potential of Glassomer's technology and aimed to create a futuristic invention that could have a global impact on a large scale.

Glassomer's accomplishments in the field of glass production have positioned them as pioneers in the industry. Their ability to transform glass into versatile, customizable shapes through 3D printing or injection molding has opened up a world of possibilities for applications in various sectors. With their innovative approach, Glassomer has overcome traditional limitations of glass manufacturing, paving the way for advancements in fields such as engineering, architecture, and healthcare.

Our challenge was part of an Attract project, which provided us with a unique opportunity to think big and develop an idea that had the potential for widespread utilization. Attract projects are known for their focus on groundbreaking innovations and are supported by substantial funding to drive research and development in various scientific domains.

To kickstart the ideation process, our team employed the "How might we" method. This approach encouraged us to explore possibilities and generate potential solutions to address the challenges presented by Glassomer's technology. Throughout this process, we brainstormed numerous "How might we" statements, each bringing us closer to our final two statements that served as the foundation for our product concept. Our chosen statements were, "How can we redesign an everyday plastic product for Glassomer to showcase the possibilities of glass 3D printing in improving plastic products?" and "How might we design a durable product for customers that satisfies their needs and reduces consumption?"

These two guiding statements immersed us in the mindset of creating the perfect product aligned with our team's vision. They provided a framework for our ideation and facilitated collaboration, enabling us to foster compromise and teamwork throughout the creative process. By exploring these statements, we aimed to explore the potential of glass 3D printing in revolutionizing plastic products and create a durable product that meets customer needs while promoting sustainability.

Through this challenge, we embarked on a journey to merge innovation, technology, and collaboration to develop a groundbreaking product concept for Glassomer. The subsequent sections of this paper will delve into the ideation process, the evolution of our product concept, and the strategic decisions made to bring our vision to life.

2 The Problem

The increasing interest in replacing plastics with glass as a more sustainable alternative has raised several potential issues that need to be carefully considered. First and foremost, glass is heavier and more fragile than plastic, which can lead to transportation and storage challenges. The breakability of glass also poses safety concerns, especially in areas where accidents or mishandling may occur. Additionally, glass production requires higher energy input and emits more carbon dioxide compared to plastic manufacturing, potentially undermining the environmental benefits. Moreover, glass recycling can be complicated and costly, as it requires specialized infrastructure and processes. This could result in lower recycling rates and increased waste if the necessary systems are not in place. Finally, the higher cost of glass compared to plastic may limit its accessibility and affordability, making it less feasible for certain industries or regions with limited resources. Balancing these considerations and finding innovative solutions will be crucial for successful integration of glass as a sustainable alternative to plastics.

However, replacing plastic with glass offers numerous benefits in terms of environmental sustainability and health. Glass is a highly recyclable material that can be reused indefinitely without any loss in quality, reducing the accumulation of waste in landfills and oceans. Unlike plastic, which can take hundreds of years to decompose, glass is non-toxic and inert, posing no harm to the environment or wildlife. Glass containers also preserve the integrity and freshness of food and beverages without leaching harmful chemicals, ensuring the safety and purity of what we consume. Moreover, glass is more aesthetically pleasing and offers a transparent view of the contents, allowing consumers to make informed choices. By switching to glass, we can significantly reduce our carbon footprint, promote a circular economy, and contribute to a healthier planet for future generations.

3 Research and Ideation

In the ideation phase, different approaches, and concepts for sustainable alternatives to everyday plastic items were developed. Creative ideas and approaches were exchanged to find innovative ways to replace plastic with glass. These methods include literature reviews, surveys, interviews, brainstorming sessions, prototyping, user testing, and collaborative workshops, fostering creativity and informed decision-making in various fields.

3.1 Early Ideas

During the ideation phase, various approaches and concepts were developed to explore sustainable alternatives to everyday plastic objects. The team aimed to generate innovative ideas to explore the use of glass as a replacement material for plastic. Here are the initial ideas in more detail:

1. Glass Can: One idea was to replace traditional aluminum cans with glass cans. Glass cans could be reusable, significantly reducing single-use aluminum consumption. Glass also offers the advantage of not affecting the taste of the beverage and being more environmentally friendly.

2. Glass Lighter Recycling System: Another approach was to develop a recycling system for glass lighters. Plastic lighters contribute to a significant waste problem as they are often disposed of after single use. By using reusable glass lighters, plastic waste could be substantially reduced.

3. Glass ID Cards, Bank Cards, and Gift Cards: The team also considered the possibility of creating ID cards, bank cards, and gift cards made of glass. These could not only be more sustainable but also provide an aesthetic and durable alternative to conventional plastic cards.

4. Reusable Glass Tea Bags: Another interesting idea was the development of special glass tea bags that are reusable. Single-use plastic tea bags generate a significant amount of waste, and using glass tea bags could help individuals reduce their ecological footprint.

5. Futuristic Glass Computer Mouse: The team also discussed the possibility of designing a futuristic computer mouse made of glass. This would not only showcase how shapes achievable only through 3D printing with glass but also demonstrate the diverse applications of glass 3D printing.

When evaluating these ideas, criteria such as sustainability, functionality, safety, feasibility and aesthetic design were taken into consideration. The team also analyzed market viability and potential environmental impact. Based on this assessment, the most promising ideas were selected as potential prototypes for further development.

The initial ideation phase as well as the recurringly thinking of the most suitable solution was crucial in exploring the variety of possibilities for the use of glass and identifying the most promising approaches for developing sustainable alternatives.

3.2 Testing

User Testing played a significant role in the development and design-thinking process of our glass-based solutions. We conducted a comprehensive online study, as well as in-person interviews, to gather insights from participants on their perceptions and experiences regarding various glass applications.

During the online study, participants were presented with different concepts and were asked to provide feedback on their usability, functionality, and overall appeal. They were encouraged to share their thoughts on how they envisioned incorporating glass into their everyday lives and whether they believed glass could effectively replace plastic in certain contexts. They were also asked to to share their concerns with the new idea regarding the security, recycability and their will to pay more for a glass alternative.

In addition to the online study, we conducted in-person interviews to delve deeper into participants' perspectives. We explored their feelings about the idea of an ID card made of glass and tried to understand their concerns, expectations, and preferences regarding such a product. Their feedback was invaluable in shaping our final design and addressing potential user concerns or reservations.

The combination of online surveys and in-person interviews allowed us to gather a diverse range of opinions and insights from a diverse group of interviewees.

This iterative process ensured that our final solutions not only met user expectations but also aligned with their needs and preferences.

User Testing was a critical component of our development process, providing us with valuable feedback and perspectives from potential users.

3.3 Solution finding

The ideas were discussed and evaluated by the team, taking into account criteria such as sustainability, functionality, safety and aesthetic design. Ultimately, the best idea was selected and considered as solution for further development.

This creative ideation phase was critical to exploring the variety of ways this specific glass could be used and identifying the most promising approaches for developing sustainable alternatives.

4 Solution

The glass ID card served as the solution to our main problem: developing an environmentally friendly alternative to conventional plastic ID cards. By using glass material, we were able to create a sustainable option that simultaneously meets the required standards for security, functionality, and aesthetics.

4.1 Overview of the solution

The glass ID card offers numerous advantages over its plastic counterparts. Firstly, it is a durable and long-lasting solution, significantly reducing the need for frequent card replacements. This not only saves resources but also minimizes the environmental footprint associated with manufacturing and disposing of plastic cards.

In addition to its sustainability benefits, the glass ID card incorporates advanced security features. These features are seamlessly integrated into the glass material itself, making it incredibly challenging to counterfeit or tamper with the card. This ensures the authenticity and integrity of the identification process, enhancing security measures and preventing fraud.

Moreover, the glass ID card allows for personalized customization. Through innovative techniques, individual information such as names, photographs, and other relevant data can be embedded directly into the glass surface. This not only enhances the aesthetic appeal of the ID card but also eliminates the need for additional plastic overlays or laminates, further reducing environmental impact.

The introduction of the glass ID card represents a significant step forward in sustainable practices and responsible consumption. By replacing plastic with glass, we are actively contributing to the reduction of plastic waste, conserving natural resources, and promoting a cleaner environment.

Overall, the glass ID card stands as an innovative and environmentally conscious solution to the problem of plastic waste in ID card production. With its sustainable attributes, advanced security features, and personalized customization options, it presents a compelling alternative that not only meets the functional requirements of an ID card but also contributes to a greener and more sustainable future.

5 Sustainability

In recent decades, awareness of our planet Earth has risen sharply and the search for sustainable alternatives in all areas of life continues to gain importance today. Progressive climate change has raised awareness of the urgent need for sustainable environmental protection. The rise in average global temperatures, loss of biodiversity, rising sea levels and increasing extreme weather events are just some of the alarming effects of climate change. These events have shown that we as a society need to take action to protect the environment from further damage and to safeguard livelihoods for future generations.

The increasing population and the resulting growth of the economy continue to lead to an increased strain on naturally occurring resources. However, the exploitation of raw materials, deforestation and the intensive use of fossil fuels are still commonplace today. Better known are the three main types of fossil raw materials as:

1. coal
2. oil
3. gas

Crude oil is the world's most widely used fossil fuel. The "black gold" is widely used in a variety of applications and plays the most important role in our global energy supply.

Especially in the transport sector, crude oil is used as the main source of energy. It serves as a raw material to produce fuels such as gasoline and diesel. In addition, crude oil also plays an important role as a feedstock to produce heating oil, lubricants, and a variety of chemical products such as fertilizers, medicines, cosmetics and, above all, in the production of plastics.

The environmental impact of high petroleum consumption worldwide is more than evident today. The extraction, transportation and combustion of petroleum leads to the release of greenhouse gases and other pollutants that contribute to climate change and thus to environmental pollution. For this reason, alternative energy sources are increasingly being sought worldwide to reduce dependence on fossil fuels and achieve a more sustainable energy supply.

There is a significant difference in the production effort between SiO2 (silicon dioxide) and plastics. Silicon dioxide is often derived from silicon, which is abundant in the form of quartz sand. The manufacturing process of SiO2 is relatively energy-intensive as it requires heating and processing.

On the other hand, the production of plastics typically involves the use of petroleum or natural gas as raw materials. These raw materials need to be extracted, refined, and chemically altered to produce the desired plastics. This process is also energy-intensive and can generate environmentally harmful byproducts.

Overall, it can be said that the production effort for SiO2 and plastics differs. SiO2 has the advantage of having an abundant starting material, but its production requires a significant amount of energy. On the other hand, plastics require the use of finite resources such as petroleum or natural gas and can also have a significant environmental impact.

With our Glassified team and the innovative idea of the glass ID-card, we want to protect the environment sustainably. But how exactly can our glass card contribute to environmental protection?

The demands on the ID card are manifold: on the one hand, it has to be highly secure and durable for 10 years, it has to make any subsequent change obvious, it has to accommodate electronic components, it has to withstand the daily physical stresses in the wallets of ID card holders and in the different climatic zones of the world - this includes pliability, scratch resistance, heat, humidity, dust, shocks, among others.

Our current ID card, both in Finland and in Germany, consists mainly of many very thin layers of polycarbonate film. It also contains tiny electronic components, such as small chips.

Using polycarbonate film brings many unique features to improve the security and durability of ID cards.

This offers, for example, excellent scratch resistance, which protects the ID card from damage in everyday use. The film is also durable and resistant to abrasion and moisture, ensuring that the information on the ID card remains legible over a longer period. Another important aspect of polycarbonate film is its ability to provide a proof increased level of security. The use of special security features such as holograms (watermarks), embossing on the film makes it much more difficult to counterfeit ID cards. These features are extremely difficult to reproduce and serve as for the authenticity of the ID card.

But there is also the other side of the coin. This is because the production of polycarbonate requires the use of petroleum as a starting material. The exact amount of petroleum depends on several unknowns, such as the manufacturing process, the efficiency of the plant and the desired quality of the plastic. In general, it can be said that up to 2.5 kilograms of petroleum are needed to produce 1 kilogram of polycarbonate. However, this figure can vary depending on the manufacturing process and other variables.

table 1: amount of plastic in circulation

	population [mio]	over age 16 (GER) / 15 (FIN) [%]	as number [mio]	weight ID-Card [g]	all plastic in circulation [t]
Germany	83	84	69,7	4,9	341,5
Finland	5,5	85	4,6	4,2	19,3

If we now take a closer look at the population figures for Finland and Germany, as shown in Table 1, it becomes clear how much plastic is in circulation in the form of ID cards in both countries. In Germany, possession of an ID card is mandatory from the 16th birthday, in Finland from the 15th. In both Germany and Finland, about 85% of the population is over the appropriate age. Finally, one multiplies the number of the population over 15 or 16 years with the respective weight of the identity card. The result is that more than 360 million tons of plastic are currently being carried around in people's wallets in the form of ID cards.

Next, the recycling process of polycarbonate is compared against that of glass. Before doing so, however, it must be mentioned that this comparison is highly generalized, and recycling depends on many different factors. Therefore, many simplifications are assumed for illustration purposes.

table 2: comparison of plastic with glass recycling

	plastic (PC)	glass (pure SiO_2)
recycling quality [%]	80	100
(before) recycling process	separated, sorted and cleaned	melted, shaped
environmental impact	may release toxins and microplastic	inert (no reactions with other components possible)
temperature [°C] / melting point	150	1600

Table 2 provides a rough overview of the two recycling processes. The first point to be considered is the quality aspect. While polycarbonate loses about 20% of its quality after recycling, the quality of the glass remains 100%, it is pure silica glass. To maintain the quality of recycled plastic, it is not uncommon to add newly manufactured plastic. But before it can start the remanufacturing process, it is necessary to make sure that there are no more toxic components in the plastic. Otherwise, the release of toxins or the like may occur during recycling. Therefore, again associated with energy to be expended, the plastic must first be sorted and then cleaned. Glass is chemically inert and does not react with other substances. This is why it is so popular as a packaging material. Therefore, the recycling process can be started directly and after the melting process, the glass can be made into new shapes. One of the biggest differences is the recycling temperature. This varies greatly depending on the material being recycled. As simplifications, let's look at the melting point of the two materials. While polycarbonate as a thermoplastic already changes its shape at 150°C, pure silica does not melt until 1600, a very big difference of about 1450°C after all.

So why "waste" a thought on glass recycling in the context of ID cards? A little leap into thermodynamics will help.

Likewise, strong simplifications are again assumed here; the main aim here is to establish a relationship between the recycling processes.

The specific heat capacity "c" is a physical property of a material and indicates how much energy is required to heat a certain amount of this material by one degree Celsius. It is measured in units of joules per kilogram and kelvin [J/(kg*k)]. Specific heat capacity depends on the chemical composition and structure of a material. Different materials have different specific heat capacities due to their respective molecular structure and the interactions between the molecules.

Formula 1 is a simplified representation of heat energy. This formula is based on the relationship between energy, mass and temperature change. This makes it possible to calculate the amount of heat energy required to heat a given substance by a given temperature.

$$\dot{Q} = m * c * \Delta\mathrm{T}$$

formula 1: heat energy Q

here:

- Q: heat energy [J]
- m: mass of the substance [g]
- c: specific heat capacity of the substance $[\frac{J}{kg*k}]$
- ΔT: temperature difference [K]

In the next step, the respective values for Germany are inserted into Formula 1, shown in Formula 2.

$$\dot{Q} = 4.9\, g * 1.17\ \frac{J}{kg * k} * \ 130\ \mathrm{K} = 0.74\ \mathrm{kJ}$$

formula 2: recycling German ID-card

here:

- weight German ID-card: 4.9 g
- specific heat capacity polycarbonate: 1.17 $\frac{J}{kg*k}$
- temperature difference $130\ \mathrm{K}$

The temperature difference results from the difference between the melting point of polycarbonate and the standard conditions, 20°C. The respective values do not need to be converted to Kelvin beforehand, since a difference remains the same no matter what unit we are in. The energy required to recycle the Finnish card is slightly less, since the card is 0.7 g lighter.

Now the energy needed to recycle the glass card is considered, also inserted in formula 1. This is illustrated in formula 3.

$$Q^{\cdot} = 6.6\, g * 0.8 \, \frac{J}{kg * k} * 1580 \text{ K} = 8.3 \text{ kJ}$$

formula 3: recycling glass ID-card

here:

- weight glass ID-card: 6.6 g
- specific heat capacity glass: $0.8 \frac{J}{kg*k}$
- temperature difference 1580 K

For illustration and dimensioning: To heat 1 kg of water by 1 K, 4.2 kJ are required.

6 Conclusion

Let´s look at all the arguments collected.

Of course, the energy to be expended for glass recycling is about 10 times higher than that for polycarbonate. Consequently, the same applies to the required recycling energy. However, the following positive aspects must also be mentioned:

- no microplastic
- no hazard components
- no more new plastic produced (for ID-cards)

Finally, here's a thought that sticks in your mind: If all identity cards in Finland and Germany alone were on glass, the world would have saved over 1000 m3 of oil!

7 Future development

In a vision of the future of the environment, the problems will not stop unless decisive action is taken. However, it is doubtful whether a glass version of the ID card could become established.

From an energy point of view, this would be advantageous for the environment, but all the necessary criteria such as durability, flexibility and protection against forgery must first be verified.

The question of how Glassomer will develop the technology of flexible glass in the coming years remains open. It is also possible that the company's research and development department will find an alternative that is even more sustainable than our glass card.

The future of 3D printed glass holds immense potential for revolutionizing various industries and pushing the boundaries of design and construction. 3D printing allows for intricate and complex geometries that traditional glass manufacturing methods struggle to achieve. With advancements in additive manufacturing technology, it is becoming increasingly possible to create customized, highly precise glass objects with intricate details. As the technology continues to develop, we can expect to see advancements in the scalability and speed of 3D printing glass, making it a more viable and cost-effective solution for various applications. The future of 3D printed glass is poised to redefine manufacturing processes, unleash creative potential, and unlock innovative possibilities in multiple industries.

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