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Ethical and Deontological Concerns

Introduction

From an ethical perspective, smart hydration products can promote healthier lifestyles and more sustainable consumption. By tracking hydration and increasing confidence in tap water quality, users may change their behavior and reduce the purchase of environmentally harmful single-use plastic bottles. Since the product is in frequent contact with the body, safety, reliability, and responsible design are essential. A product must be safe, reliable, and meet legal standards. Addressing these aspects helps create a responsible and sustainable solution. This chapter evaluates ethical considerations from the perspectives of engineering duties, environmental impact, sales and marketing ethics, and product liability.

Engineering Ethics

Engineering ethics refers to the moral responsibilities and professional standards that guide engineers in designing and developing technology. It focuses on protecting public and individual safety, acting honestly and objectively, working within one's competence, and ensuring fairness and transparency in technical decisions and communication. Ethical engineering also includes resisting misleading marketing, avoiding conflicts of interest, and contributing to sustainable and socially beneficial innovations. Ultimately, engineering ethics ensures that technological progress serves people, society, and the environment in a responsible way.

The following section explains some of the responsibilities and duties of engineers and then applies them to our project. These duties are based, on the one hand, on the course content [1] and, on the other hand, on the German fundamental ethical principles of the engineering profession [2].

The duty to oppose unfair competition means that engineers have the responsibility to act fairly in the market and avoid misleading practices that could harm competitors or deceive customers. This includes making accurate performance claims and respecting intellectual property, such as patents and protected designs. Engineers must avoid copying patented bottle mechanisms for example the sterilization technologies from other brands. Fair competition ensures trust in engineering solutions and protects innovation. We therefore specifically sought out alternative solutions, such as a combination of various features already available on the market. Moreover, engineers and companies must communicate product capabilities realistically and responsibly, without exaggerating benefits. Especially with technologies like UV-C sterilization, it is important to explain that the system reduces microorganisms but does not necessarily remove all contaminants. For example, we cannot guarantee 100 % the destruction of microorganisms. Nor can we guarantee complete drinkability through the bottles, because the bottle does not cover comprehensive drinking water tests. This must be made clear in our communication with customers. Another issue is the recommended daily water intake, which is highly individual and depends on many factors that are not adequately addressed in the app or when setting the daily drinking goal. Transparency with customers must also be established in this regard.

This duty is similar to the duty of sobriety in advertising. It means that engineers and companies must communicate product capabilities realistically and responsibly, without exaggerating benefits. Advertising should therefore focus on evidence-based advantages, such as improved hygiene or convenience. Clear communication helps users make informed decisions and prevents false

expectations that could lead to unsafe usage. Engineers should only take responsibility for tasks that match their technical expertise and time capacity. Developing smart products requires interdisciplinary knowledge, for example in electronics, informatics, design, materials science as well as in water chemistry and medicine. An engineer designing a smart bottle should therefore collaborate with electrical or biomedical specialists when integrating UV-C systems, filters, or sensor electronics. For the development of TRAQUA, this means that we must increasingly engage with fields not represented within the group, such as medicine and water chemistry. In addition to scientific papers, experts are being consulted on this matter.

Another duty is the duty of non-discrimination. Engineering solutions should be designed to be inclusive, accessible, and beneficial to a wide range of users. This includes considering different physical abilities, ages, and technological familiarity. For example, a smart bottle system could include voice control or audio feedback in the app to support visually impaired users, or simple visual indicators for elderly users. Inclusive design increases product reach and ensures that technological innovation benefits society as a whole rather than only a limited user group.

Across all these duties, user safety must remain the highest priority, especially when integrating technologies such as UV-C light and electronics into consumer products. Engineers must ensure that UV-C radiation is fully contained within the device so that no direct exposure can harm the user's skin or eyes. Materials used in contact with water must be food-safe, non-toxic, and resistant to degradation, preventing contamination or health risks. Additionally, the product must be designed to be fully water-resistant and electrically safe, guaranteeing that under no circumstances electrical current can enter the water and injure the user.

Sales and Marketing Ethics

Sales and marketing ethics play a central role in ensuring that innovative products such as TRAQUA are introduced to the market in a responsible, transparent, and user-oriented way. At the core of this lies communication. The strengths of the bottle must be communicated clearly and honestly, without exaggeration or omission of relevant limitations. The marketing strategy should therefore be built on transparency and credibility. In line with the slogan "trust your bottle, know your bottle," trust should not only be placed in the data provided by the bottle itself, but also in the way the product is presented and advertised. Trust in the technology as well as in the communication surrounding is inseparable.

This creates tension between the marketing aims to highlight the benefits of the product on the one hand and the open communication about limitations on the other. For example, the effectiveness and boundaries of UV-C cleaning must be explained realistically, without creating a false sense of complete safety. Similarly, it is essential to avoid any form of greenwashing. Sustainability claims must be substantiated, which is why the results of the Life Cycle Assessment are disclosed transparently. This includes not only positive aspects but also environmental drawbacks, such as the use of electronic components, as well as the need to replace parts like the filter, battery, or UV-C module over time. Health-related recommendations must also be communicated carefully, making it clear that they are based on general guidelines rather than medical certification.

Pricing represents another important ethical dimension. As a smart product, the bottle will be positioned at a higher price level compared to conventional reusable bottles. This raises questions of accessibility and fairness. However, the perception of price strongly depends on the point of comparison. When compared to standard reusable bottles, the product may appear expensive. In contrast, when compared to the long-term use of single-use plastic bottles, the cost can be

contextualized differently. A user who switches from buying bottled water daily to using tap water with TRAQUA may reduce expenses over time. Nevertheless, it must be acknowledged that the product will not be accessible to everyone and is primarily targeted at consumers who have the financial means to invest in lifestyle-enhancing, but non-essential, products. Closely linked to pricing is the question of durability. Traditional reusable bottles often suffer from limited lifespan due to inadequate or irregular cleaning, leading to biofilm formation and eventual replacement. In the case of plastic bottles, the potential release of microplastics further complicates their long-term use. TRAQUA addresses these issues through its self-cleaning functionality and the use of an aluminium interior, which reduces both hygiene concerns and material degradation. At the same time, it must be acknowledged that durability is not only a product feature but also depends on user behaviour, particularly cleaning habits. Moreover, the integration of electronic components introduces new limitations. Batteries, sensors, and UV-C elements have finite lifespans. To address this, the product is designed as a modular three-part system that allows for the replacement of individual components without requiring the entire bottle to be discarded. This reflects an attempt to balance technological functionality with long-term sustainability.

Another important aspect of marketing ethics concerns data security and user privacy. As a smart product, TRAQUA may collect and process user-related data, such as hydration patterns or usage behaviour. Ethical marketing requires that users are clearly informed about what data is collected, how it is stored, and for what purposes it is used. Data collection should be minimized to what is strictly necessary, and users should retain control over their information. Transparent communication about data practices, combined with secure handling of personal data, is essential to maintain trust and prevent misuse. In this context, ethical responsibility extends beyond the physical product to the digital ecosystem in which it operates.

Inclusivity and accessibility must also be integrated into both communication and distribution strategies. Ethical marketing should aim to make the product understandable and usable for a diverse range of users, for example through features such as audio feedback for visually impaired individuals. At the same time, there are clear limits. The product cannot replace medical supervision for individuals with serious health conditions requiring controlled hydration. It is therefore important to clearly define the target group, which in this case consists primarily of young, active users seeking a convenient and sustainable way to manage their hydration.

From a sales perspective, combining online distribution with physical retail can improve accessibility and allow users to experience the product directly. First, the option of selling the product through online channels must be carefully evaluated. Online retail is often associated with longer transportation distances and the resulting environmental impacts. While it enables broad, even international accessibility, it also relies on a complex infrastructure of packaging, shipping, and delivery services that can gradually displace local retail structures. In addition, online shopping may encourage less conscious consumption behaviour, as products can be ordered quickly and are often returned, leading to additional transport emissions. Packaging is another critical issue, as it contributes negatively to the overall environmental footprint. TRAQUA addresses this by using packaging that is designed to be reusable or to have a reduced environmental impact.

Within online sales, a distinction can be made between direct sales via a dedicated website and distribution through large e-commerce platforms such as Amazon. From an ethical perspective, these channels differ significantly. Large platforms offer the advantage of reaching a wide customer base without requiring users to actively search for the product, which makes them economically attractive. However, they also contribute to market imbalances, where large corporations benefit disproportionately, potentially disadvantaging smaller businesses. Furthermore, the handling of customer data on such platforms is often not fully transparent, raising concerns about data privacy and ethical data use.

In contrast, more direct and localized sales channels can support regional businesses, reduce transportation distances, and minimize packaging requirements. This approach can foster more conscious consumption and strengthen local economies. However, it also limits accessibility, as physical retailers are not available everywhere and may not reach all potential users.

For this reason, TRAQUA follows a balanced distribution strategy. The product will be available online, with a preference for direct sales through dedicated websites rather than relying heavily on large e-commerce platforms. At the same time, TRAQUA will be offered through selected retail partners, particularly premium and sports-oriented stores. This combined approach aims to balance accessibility, environmental responsibility, and ethical considerations in both sales and distribution.

The brand itself must also be protected. It is therefore important not to copy brand names or logos from other companies. For example, there is already a company called TRAQUA. It operates in the fields of hydrology and hydrogeology in Belgium. Since both its area of expertise and its logo and slogan differ completely from the branding concept for the smart water bottle, this does not constitute an infringing encroachment on the market.

Environmental Ethics

Environmental ethics in product development focus on minimizing ecological impact while encouraging more sustainable user behavior. As already mentioned in the section on engineering ethics, durability is an important aspect. Ensuring a battery with sufficient energy capacity and long lifecycle also contributes to sustainability by lowering the frequency of replacements and reducing electronic waste.

Material selection plays an important role. Aluminium as a primary structural material it is highly durable and fully recyclable. In addition, the design should enable easy replacement of wear components, such as filters that require regular exchange. A modular construction allows users to replace individual parts instead of discarding the entire product, further extending product lifespan and reducing waste.

Environmental impact is also reduced through local manufacturing and local marketing strategies, which help minimize transportation distances and associated carbon emissions. By strengthening regional supply chains and distribution channels, companies can lower their overall environmental footprint.

Finally, smart hydration products are contribute to broader behavioral change. By addressing common drawbacks of conventional reusable bottles, such as uncertainty about tap water quality and rapid microbial contamination, they can encourage more people to switch away from single-use plastic bottles. This shift supports waste reduction and promotes more sustainable consumption habits, demonstrating how environmentally responsible design can influence both product performance and long-term user behavior.

Liability

To ensure safe use and minimize legal risks, smart water products must follow strict safety, transparency, and regulatory principles throughout design, communication, and operation.

Electrical & Water Safety

- Fully water resistant design to prevent any contact between electricity and drinking water
- Fail-safe engineering: even if the device is damaged or malfunctions, users must not be harmed
- Compliance with electrical safety standards, compliance with low voltage standards [3]
- Compliance with electromagnetic compatibility (EMC) standards to prevent interference or unsafe operation [4]
- Compliance with low voltage standards [5]

UV-C Radiation Safety

- UV-C light must be fully contained inside the device [6], [7]
- Protection mechanisms must prevent any risk of skin or eye exposure
- Material & Food Safety
- Use of food-safe [8] non-toxic, corrosion-resistant materials
- Long-term material durability and hygiene stability

Battery Safety

- Reliable battery with stable energy capacity
- Protection against overheating, leakage, or short circuits
- Safe integration in wet environments
- Avoid overheating the battery components

Performance Transparency

- Only claims regarding realistic cleaning results or realistic measurement accuracy
- Clear communication of technical limitations
- Step-by-step instructions for safe use and maintenance
- Clear information about filter replacement and cleaning cycles
- Transparent communication to build customer trust

Data Security

- Secure handling of hydration or usage data
- Encrypted communication and responsible storage
- Transparent privacy policies for users

Summary

Based on this ethical and deontological analysis, the team chose to integrate features that improve user safety, promote healthier hydration habits, and reduce environmental impact. Ethical considerations included ensuring safe contact with drinking water, preventing UV-C exposure and electrical risks, using food-safe and durable materials, and encouraging sustainable behavior by reducing dependence on single-use plastic bottles. Additionally, inclusivity and transparency were important factors, aiming to support a wide range of users and provide trustworthy information about

product performance.

Consequently, the team decided to design a solution with a user-safe UV-C hygiene support, hydration and volume tracking, modular and replaceable components such as filters, durable recyclable materials, and clear user guidance through digital feedback or app connectivity. These features were added to create a product that is safe, reliable, environmentally responsible, and ethically aligned with long-term user well-being and sustainable consumption.

[1] Luís Cardia, 2026. *Ethics & Deontology in Engineering 2026*. [Accessed in March 2026].

[2] VDI Verein Deutscher Ingenieure e.V, 2026. *Ethische Grundsätze des Ingenieurberufs*.

International Journal of Medical Science in Clinical Research and Review, [Accessed in March 2026]: VDI Verein Deutscher Ingenieure e.V.

[3] European Commission, 2001. *Low Voltage Directive (LVD)*. [Accessed in March 2026].

[4] European Commission, 2014. *Study on the Evaluation of the Electromagnetic Compatibility Directive 2014/30/EU (EMCD)*. [Accessed in March 2026].

[5], [8] European Commission, 2026. *Food Contact Materials*. [Accessed in March 2026].

[6] European Commission, 2017. *UV-C-lamps: could something that kills bacteria and viruses also harm you?*. [Accessed in March 2026].

[7] European Commission, 2017. *Health effects of UV-C lamp radiation Final version Scientific Committee on Health, Environmental and Emerging Risks*. [Accessed in March 2026].

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