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6. Ethical and Deontological Concerns

This chapter explains the role of ethics in engineering and briefly introduces deontological ethics as a way to understand moral responsibility in decision-making. It also discusses engineering ethics and the standards that guide professional behavior, including codes created by the National Society of Professional Engineers (NSPE). These principles affect engineering decisions, design processes, and professional actions **[1]**.

For Screen2Green, ethics is especially important because the project combines electronics, water systems, user behavior tracking, and plant care. This chapter focuses on the main ethical issues related to the project, such as safety, responsible behavior design, data privacy, professional competence, sales and marketing ethics, environmental responsibility, plant welfare, and liability. These topics help make sure that the final product is safe, responsible, and sustainable for both users and the environment.

6.1 Engineering Ethics

Engineering ethics refers to the principles and responsibilities that engineers are expected to follow in their professional work. These principles are important because engineering decisions can directly affect people's safety, daily lives, and the environment. Following ethical standards helps ensure that projects are designed and carried out in a safe, reliable, and responsible way.

Engineers are expected to consider not only the goals of their company, but also the needs of clients, users, and the wider public when making decisions. Ethical principles also influence how systems are designed, tested, and implemented, helping to reduce risks and improve reliability. By following professional standards, engineers can help build public trust and maintain the credibility of the profession **[2]**.

6.1.1 Understanding the Engineering Code of Ethics

A well-known example of engineering ethics is the code of ethics developed by NSPE. This code outlines the main responsibilities that engineers are expected to follow in their professional work.

According to the NSPE engineers should prioritize public safety, health, and welfare, and only carry out work in areas where they have the necessary knowledge and skills. They are also expected to communicate honestly, avoid deceptive actions, and act responsibly toward clients, employers, and the public.

In addition to these core principles, the code includes further professional obligations that help guide ethical decision-making in different situations. These standards are important because they help engineers maintain professional integrity and protect public trust in the engineering field **[3]**.

6.1.2 The Importance of Ethics in Engineering

Ethics plays an important role in engineering because engineering decisions can directly affect people, organizations, and the environment. One of the main reasons ethics is important is safety.

Engineers are responsible for making sure that the systems they design and develop do not create unnecessary risks for users or the public. Following ethical standards helps prevent accidents, reduce harm, and create safer working environments.

Ethics is also closely related to the quality of engineering work. Engineers are expected to work within their area of knowledge and take responsibility for the reliability of their designs. This helps reduce mistakes and improves the overall quality of projects. In professional settings, ethical behavior also supports teamwork, good communication, and responsible leadership.

Another important aspect is public trust. Engineers often work on systems that affect people's daily lives, so honest communication and responsible decision-making are essential. Acting ethically helps build confidence in both the engineer and the profession as a whole.

In addition, ethics supports sustainability and long-term responsibility. Engineers should consider not only short-term project goals, but also the wider social and environmental impact of their work. This includes using resources responsibly and thinking about how current decisions may affect future users.

Finally, ethical standards help protect both organizations and professionals. They support fair treatment, respect for intellectual property, confidentiality, and professional integrity. By following ethical principles, engineers can contribute to safer systems, stronger organizations, and more responsible innovation **[4]**.

6.1.3 Safety of the system

Safety is one of the most important considerations in engineering design. This system combines electronics, water, and plant care, which creates possible risks such as water leakage, electrical faults, or damage to nearby objects. To reduce these risks, the design needs to include proper water containment and reliable components. Safe operation is important not only for the user, but also for the environment where the system is used.

The system relies on sensors and automated control technologies to monitor conditions such as soil moisture in real time **[5][6]**. While this improves convenience and efficiency, it also creates challenges because water and electronic components are used together.

System Characteristics and Safety Risks

The system uses sensors, microcontrollers, and water supply devices to control irrigation automatically based on real-time data **[7]**. This improves efficiency, but it also introduces some important risks. One key issue is sensor accuracy and overall system reliability. If the sensor gives incorrect readings or the system malfunctions, the plant may receive too much or too little water. This can reduce system performance and negatively affect plant health **[8]**.

Another important risk is moisture exposure. Since the system operates in a humid environment, water ingress can damage electronic components, reduce performance, and lead to system failure **[9]**. For this reason, protection against water and dust is an important part of the design. The International Electrotechnical Commission defines protection levels through the Ingress Protection (IP)rating system, which is widely used as a guideline for products exposed to water **[10]**.

Safety Design Strategies

To reduce these risks, several safety measures should be included in the design. First, water and electronic components should be clearly separated. Waterproof enclosures, sealed structures, and proper layout design can help prevent moisture from reaching sensitive parts. Using suitable IP-rated protection can further improve safety **[11]**. Second, the system should use reliable sensors and continuous monitoring to maintain stable operation. Accurate soil moisture readings are important for precise irrigation control and for detecting unusual conditions early **[12]**. Finally, fail-safe features should be included. The system should be able to stop automatically if an abnormal condition is detected, helping to prevent damage. Threshold-based control can also reduce the risk of overwatering, and the design should allow the system to remain in a safe state even if a failure occurs.

6.1.4 Responsible behavior design

Responsible behavior design means creating systems that can influence user actions while still respecting important ethical values such as autonomy and well-being. As digital technologies become more involved in daily life, it is important to make sure that these systems encourage positive habits without limiting users' freedom to make their own choices.

Ethical Persuasion and User Well-being

Since this system is designed to influence user behavior, it should avoid persuasive methods that feel manipulative or harmful. Research on persuasive technology shows that systems can raise ethical concerns when they create pressure, exploit users' weaknesses, or reduce their sense of control **[13]**. For this reason, the goal of Screen2Green should be to support healthier digital habits in a positive way, rather than making users feel guilty or stressed when they their screen-time limits. A design that creates too much pressure could reduce users' sense of autonomy and make the system less ethical.

Motivation and Behavior Change

This idea is also supported by motivation research. According to the Self-Determination Theory, autonomy is an important psychological need, and people are more likely to stay motivated when they feel that their actions are self-directed **[14]**. This suggests that the system should help users make healthier choices by encouraging awareness and reflection, rather than using strict or controlling methods. Supporting users' sense of choice can lead to more meaningful and lasting behavior change.

System Design Considerations

In addition, the system should make sure that any effects on the plant stay within safe biological limits. The plant should never be harmed as part of the behavior change process. Even if the system is designed to motivate users, plant health must remain a priority. Although most persuasive technology research focuses on users, designers also have a responsibility to consider the wider effects of the system. In this project, that means making sure that any interaction linked to the plant

still allows it to grow in healthy and safe conditions.

6.1.5 Data privacy

The system collects screen-time data through an associated application. Because this information is linked to users' daily habits, ethical data management is an important part of the design. Users should clearly understand what data is being collected, how it will be stored, and how it will be used. Data collection should only begin after informed consent is given, and the system should avoid collecting sensitive personal information unless it is necessary for the system to work properly.

Even with these principles, privacy and security challenges can still arise when this type of system is used in a home smart farming environment. Many of these systems rely on low-cost IoT devices, which often have limited processing power and weaker built-in security. This can make them more vulnerable to cyber threats.

Threats

One of the main concerns is the sensitivity of screen-time data. If this information is accessed without permission, it may reveal users' routines, habits, and daily schedules. In addition, the system also collects environmental data such as soil moisture, temperature, humidity, and light levels to support plant growth. Although this environmental data may seem less sensitive, it can still reveal patterns about user behavior or home occupancy when collected over time. Because of this, the system may be exposed to risks such as unauthorized access, data interception, or manipulation of sensor readings. For example, false soil moisture data could cause incorrect irrigation, which may harm plant health and reduce system reliability **[15][16]**. At the same time, improving security in IoT systems is not always simple. Strong encryption can improve protection, but in low-power devices it may also increase energy use and reduce system efficiency. This creates an important trade-off between security and energy consumption, which needs to be considered carefully **[17]**.

Strategies

To reduce these risks, several practical strategies can be applied. First, lightweight encryption methods can help protect important data while keeping energy use low. A balanced approach should also be used for data protection. More sensitive information, such as screen-time data, should have stronger security, while less sensitive environmental data can use lighter protection methods. Second, edge computing can improve both privacy and efficiency by processing data locally instead of constantly sending it to external servers. Sending data in batches rather than continuously can also reduce communication frequency and save energy.

Finally, transparency and system maintenance are essential. Users should be able to easily understand how their data is collected and used through clear privacy settings, simple policies, and notifications. Regular software updates, strong authentication methods, and anomaly detection systems should also be included to improve overall security. For example, unusual soil moisture patterns could help detect possible cyberattacks or system faults before serious problems occur.

6.1.6 Professional competence

Professional competence means that engineers have the knowledge and skills needed to carry out their work safely, responsibly, and effectively. In engineering projects, this also means following professional standards and ethical principles throughout the design process. For this system, professional competence is important because the design involves electronics, water, sensors, and user-related data. Engineers need to make sure that the system is safe, reliable, and suitable for its intended use. This includes considering user safety, protecting privacy, and reducing possible risks during both development and operation.

Professional competence also means recognizing the limits of one's own knowledge. If a problem goes beyond an engineer's expertise, it is important to seek support, collaborate with others, or consult relevant technical standards. This helps reduce mistakes and improves the overall quality of the system. In addition, engineers should continue updating their knowledge as technologies develop. Since systems like this depend on sensors, automated control, and digital applications, keeping up with new technologies is important for making informed design decisions. Finally, proper testing and validation are essential. The system should be tested under different conditions to make sure it works correctly and safely. By maintaining professional competence, engineers can improve system performance while also meeting their ethical responsibility to protect users and maintain public trust.

6.2 Sales and Marketing Ethics

Sales and marketing ethics are important because the way a product is presented can affect how users understand it and how they use it. This is especially important for Screen2Green, since the product is meant to help users build healthier screen-time habits. Because Screen2Green uses technology, user feedback, and behavior change features, it is important to present the product in a clear and honest way. Users should understand what the system does, what its limits are, and what they can expect from using it.

This section discusses the main ethical issues related to how Screen2Green should be presented to users. It focuses on honest communication, avoiding manipulative marketing, being clear about how the system works, and considering younger users who may be more sensitive to digital influence.

6.2.1 Honest communication and avoiding manipulative marketing

The product should be marketed with clear and honest communication about its functionality and purpose. Marketing materials should accurately describe what the device does, how it influences user behavior, and what benefits users can realistically expect. Clear communication is especially important in digital well-being products, as users need to understand both the purpose and the limits of the system in order to trust it and use it properly **[18]**.

Additionally, since the product focuses on digital well-being and screen-time awareness, it is important to avoid marketing strategies that create anxiety, guilt, or fear about technology use. The aim of Screen2Green is to support healthier habits in a positive way, not to pressure users or make them feel bad about their behavior. Research on persuasive technologies shows that overly controlling designs can reduce user autonomy and may even cause stress **[19]**.

6.2.2 Transparency and target users

Users should clearly understand how the system works before using it. This includes how screen time is monitored, how the plant responds to user behavior, and what type of data is collected. Providing this information clearly helps users make informed decisions and increases trust in the product **[20]**. If the product is used by children or teenagers, additional ethical considerations are needed. Younger users are generally more vulnerable to persuasive technologies and may be more easily influenced by digital feedback systems. For this reason, the system should avoid strong behavioral pressure and include suitable safeguards if designed for younger users **[21]**.

6.3 Environmental Ethics

Environmental ethics is an important part of the Screen2Green project because the system is not only a digital product, but also something that directly interacts with a living plant. Since the project uses electronic parts, sensors, and a watering system, it is important to think about how the design may affect the environment. This is not only about reducing the electricity used by the device, but also about choosing suitable materials, making the product last longer, and making sure the plant is cared for properly. A good design should avoid creating unnecessary waste and should allow parts to be repaired or replaced when needed. Because the project is meant to encourage better daily habits, it should also reflect responsible choices in its own design. For this reason, environmental ethics in Screen2Green focuses on energy use, material selection, and plant welfare to make sure the system is practical, sustainable, and respectful of the environment.

6.3.1 Energy use

Modern digital technologies consume significant amounts of energy. Smartphones, applications and online services all depend on servers and data centers that operate continuously and contribute to carbon emissions because they require constant electricity. Moreover, increased screen time raises the overall energy demand once again **[22]**.

According to the International Energy Agency, the Information and Communication Technology (ICT) sector is a rapidly increasing contributor to global energy use **[23]**.

This creates an ethical challenge: as technology becomes more integrated into daily life, both users and developers must consider its environmental impact.

From an ethical perspective, Screen2Green aligns with:

- Utilitarianism: reduced energy use benefits society and the planet
- Deontology: individuals and developers have a duty to minimize environmental harm
- Deep ecology: nature has intrinsic value and deserves respect

By encouraging more mindful screen use, Screen2Green may help reduce unnecessary energy use while also promoting environmental awareness. In addition, the system is designed with low-power electronic components such as an ESP32 microcontroller and simple environmental sensors, which helps keep the device’s own energy consumption relatively low.

Screen2Green shows how innovative design can support more responsible habits while considering environmental impact.

6.3.2 Materials

Ethical product design also includes thinking about the materials used in the device, how long they last, and whether they can be repaired or recycled. A modular design with replaceable parts can make the product last longer and reduce environmental impact.

For the prototype, the main structure was planned using PLA, which is lightweight and commonly used in 3D printing because it is easy to manufacture. A cork base was also considered to improve stability and provide some insulation. The internal system includes common electronic parts such as an ESP32 microcontroller, relay module, sensors, and a solenoid valve for the watering system.

This combination of simple materials and modular parts makes maintenance easier and allows damaged parts to be replaced without throwing away the whole product. Previous studies also suggest that modular design can help products last longer and make repair easier, which can reduce waste over time **[24]**.

The material choice was also considered in the life cycle analysis in order to reduce waste and improve long-term durability.

6.3.3 Plant welfare

Since the plant plays a role in the behavior feedback system, ethical considerations must also include plant welfare. The plant should not be exposed to harmful conditions as part of the system. Any changes to watering or light levels must stay within safe biological limits to make sure the plant remains healthy.

To support this, the system uses soil moisture and temperature sensors to check the plant’s condition and give more accurate feedback. The watering system was designed with safe limits so that overwatering or underwatering can be avoided as much as possible. This is important because incorrect watering can damage roots, slow growth, and affect the plant’s overall health.

Previous studies on smart irrigation systems also suggest that sensor-based monitoring can help improve watering accuracy and support healthier plant growth **[25]**. For this reason, the system should also include clear safety limits and allow users to water the plant manually when needed, so that the plant’s health is always more important than the feedback system.

6.4 Liability

Liability is an important issue in the Screen2Green project because the product combines electronics, water, a physical plant, an app, and digital monitoring. If one part does not work correctly, it may affect the user, nearby objects, the plant, or the user’s data. For example, sensor errors, water leakage, software problems, or wrong irrigation decisions could damage the plant or make the product less reliable.

Regarding the physical product, the main risks are related to water and electronics. The watering system depends on sensor data, such as soil moisture, to decide when the plant needs water. Soil moisture sensors are commonly used in smart irrigation technology to help decide when irrigation is needed. Therefore, possible failures should be considered from the early design stage. The product should use reliable components, proper testing, waterproof protection, safe watering limits, alerts for

abnormal conditions, and a manual override function. These features can help reduce risks and make sure that the plant's health is not fully dependent on automatic feedback **[26]**.

Liability also includes privacy and data protection. Since Screen2Green may collect screen-time and behavior-related data, users should clearly know what data is collected, why it is needed, how long it is stored, and whether it is shared with third parties. The system should follow GDPR principles such as transparency, purpose limitation, data minimization, and secure processing. Users should also be able to control their data, including requesting deletion when needed **[27]**. If the app uses tracking, analytics, cookies, or similar technologies, the European Union (EU) ePrivacy Directive should also be considered. This is because these tools may store or read information on the user's device. Therefore, users should be clearly informed and asked for consent when this kind of tracking is used **[28]**.

Another important responsibility is the user's mental well-being. Screen2Green should help users build healthier screen habits, but it should not do this by making them feel guilty or ashamed. The app should avoid stressful notifications, dark patterns, addictive reward loops, and strong failure messages. Dark patterns are a problem because they can steer, deceive, coerce, or manipulate users into choices that are not in their best interest. For example, if the user does not reduce their screen time, the app should not punish the user or make the plant look like it is suffering. A better approach would be to recognize small efforts, suggest a smaller goal, and encourage the user to try again **[29]**.

The product should also keep a clear boundary from medical devices. Screen2Green should be presented as a well-being or lifestyle tool, not as a medical treatment. Claims such as "treats Attention-Deficit/Hyperactivity Disorder", "cures phone addiction", "improves depression", or "diagnoses mental health issues" should be avoided because they could make the product seem like a medical solution. Under the EU Medical Device Regulation, software can be included in the definition of a medical device when it is intended for a medical purpose. Safer wording would be "supports mindful phone use", "encourages healthier screen habits", or "well-being-oriented focus tool" **[30]**.

Cybersecurity is also part of liability because the app is connected to a digital device. The system should protect communication between the app and the product, store user data securely, and provide software updates if problems are found. It should also consider possible unauthorized access or security vulnerabilities. The EU Cyber Resilience Act focuses on cybersecurity for hardware and software products with digital elements, including issues such as weak security and lack of timely security updates. This is important because poor cybersecurity could affect both user privacy and the safe operation of the product **[31]**.

Because the plant is part of the feedback system, the team also has responsibility for plant welfare. The system should not use behavior feedback in a way that harms the plant. Manual override and safe watering limits are important because the plant's health should always be more important than the feedback mechanism.

Sustainability and accessibility should also be considered as part of responsible product design. Since Screen2Green connects technology with nature, the product should consider repairability, long product lifespan, energy-efficient components, and reduced electronic waste. EU repair policy also supports more sustainable consumption by increasing the repair and reuse of goods **[32]**. The app should also be easy to use for different users. This includes readable text, enough color contrast, simple onboarding, a calm interface, and not using color as the only way to show important information. Web Content Accessibility Guidelines explain that color should not be the only visual way to communicate information **[33]**.

Overall, liability in Screen2Green means reducing possible risks through safe design, clear communication, responsible data handling, cybersecurity, and ethical feedback. The product should

support healthier screen habits without manipulation or punishment, while also protecting the user, the plant, and the product itself.

6.5 Summary

This chapter looked at the main ethical and deontological issues related to Screen2Green, such as safety, user privacy, behavior design, environmental impact, plant welfare, and liability. Through this analysis, the team understood that the system should not only work properly, but also be safe, clear to users, and responsible in the way it affects both people and plants.

Based on this ethical and deontological analysis, the team chose a modular design with simple monitoring components, a soil moisture sensor, an ESP32 microcontroller, a controlled watering system, waterproof protection, and low-cost recyclable materials. These choices were made to reduce possible risks, protect plant health, support responsible data use, and make the product easier to maintain.

Consequently, the team decided to include features such as safe watering limits, basic fail-safe protection, clear user information, modular parts, and behavior feedback that supports users without creating pressure. These features help make the system safer, easier to use, and more suitable for daily use.

This chapter also helped guide the team's technical decisions and gives a clear basis for the next chapter, which explains how these ideas were applied in the system design and development process.

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