Content

1.   Problem Statement

1.1 Introduction

The challenge that was presented by the challenge collaborators Susanne Grohs-von Reichenbach and Eslam Shoaala focused on the topic of digital waste. This refers to unnecessary and redundant digital data that is stored, processed, and calculated across systems, software, and data servers. It can also include the data, which is outdated, duplicated or not useful anymore. Such digital waste can lead to negative consequences, such as increased storage costs, decreased system performance and potential security risks. In addition, storing unnecessary data can contribute to higher energy consumption, as it requires additional computing power to process and store data, which directly implies that digital data waste causes unnecessary carbon footprint!

The computing industry contributes to 2 percent of global carbon emissions, like the global aviation industry.[1]

Therefore, even though it is evident that the software industry has a significant impact on the world by its revolutionary innovations and products, which leave a positive impact on every other stream from communication to healthcare; the term "digital carbon footprint" is not so commonly used among end users and practitioners such as software engineers. Hence, along with the rising need to act for the sustainable future of humankind, it is imperative to raise awareness among software engineers about the relevance of reducing digital waste as well as considering the environmental impact of software products. The concept of the digital footprint should become a more widely recognized term in the software industry, boosting more sustainable practices and greater consideration for the planet during software development.

1.2 Our approach to the problem

Initially, when the challenge was presented to our team, which consists of students of non-software disciplines, we had little to no idea about the impact that the software industry could have on both climate change and carbon footprint. However, during our research about the topic we learned that the impact of the software industry on carbon footprint is about half as big as the aviation industry. *There's the information and communications technology sector as whole. By 2040, it is expected to account for 14% of the world's carbon footprint — up from about 1.5% in 2007.* [2]

Not only these figures are disheartening, but also devastating for the future of the software industry. Thus, we asked ourselves about how we could contribute in a way that our solution may play a key role to help reduce the expected carbon footprint, as well as how it could be integrated in the theme of the EuroTeQ collider which was 'Leaving No Waste Behind' and the time of the respective course.

During our brainstorming sessions, we came up with numerous ideas regarding how to deal with this problem. Some of them were as follows:

(1) Creating a collaborative platform which would enable to share and re-utilize the codes sequences and components within the user company. Likewise, we could also create a library, which can be connected to all the company's devices, and even can be team up with other companies or other universities to make it wider in content. This platform could help to save enormous amounts of energy, time, money, and even hardware, which in turn would lead to lower digital carbon footprint.

(2) Developing a browser extension, which calculates the online traffic for the webpage and calculates the carbon footprint which is generated due to usage.

(3) Carbon Offsetting Integration, which is a mediator platform between software firms and offsetting carbon footprint organizations. Some tech giants such as Google, Microsoft, and Apple purchase bonds to maintain the sustainable and carbon net zero image. However, it is hard for small-scale software firms to purchase such offsets. Therefore, this kind of carbon offsetting integration platform would aim to enable access to such offsetting practices in an easier manner.

(4) Creating a carbon footprint calculator, which are the kind of tools that work on the exact principles as LCA (Life Cycle Assessment) instruments. For the calculation part the user needs to enter information about the software or website usage such as the number of users, hardware, and energy use. Then in the next step, the calculator would give the user the evaluated results and show carbon emissions by the specific activity.

(5) Comparison of GHG emissions with day-to-day activity, this idea refers to non-software professionals who utilize the final product such as any software, smart phone apps and websites in their day-to-day work life but, not aware of the impact of their utilization. To elaborate more, as an example, if a user utilizes a webpage for about two hours, this would be equivalent to GHG emissions to drive a car for 20 minutes. These tips are aimed to give more simplified understanding for their online activities and their impact on climate change.

To summarize, after having these intense brainstorming sessions we concluded that, creating a browser extension or developing our own carbon footprint calculator was not feasible for two reasons. First, the course period was limited, and to develop a solution that would act as a footprint calculator would have been an intensive process. Secondly, our team's expertise lies more in the sustainability field and not in software development. Moreover, there are already some footprint calculators available which are open source. For that reason, creating our own software/tool would not give us any competitive advantage over others. Therefore, after pondering our thoughts, we finally decided to solely focus on the awareness part and provide the already available tools in case of needed references.

2. Methodology

2.1 Visiting Workday

To get the extent and seriousness of the problem, the team decided to spend an entire day with one of our mentors, Eslam Shoaala, who works as a software engineer at Workday GmbH. A day in the life of a software engineer, where we noticed the challenges that a software engineer faces to implement sustainable practices in their everyday work tasks. We also discussed about topics like the importance of sustainability in software development and which methods/ways they exert in their daily life and their work life to contribute to a sustainable future. Besides that, our team also interviewed another software engineer who was working with Eslam that day at Workday GmbH. As we were expecting, her answers stated little to no influence of sustainability practices in everyday software development steps. According to her, the primary focus while developing any software are security, feasibility, efficiency, and result oriented codes. The emphasis given to the green code or energy efficiency is low, which leads to high energy intensive software products, that in turn mean higher carbon emissions.

After getting the answers from the workday's software engineers, it provoked us to think more about the lack of awareness regarding sustainability among the software developers. To prove our findings, our team decided to conduct a survey, which is covered in the upcoming section.

As portrayed below in the photograph of our day at Workday GmbH, our happy faces highlight the avidness and great drive to make change and contribute to a more sustainable future.

Figure 1 Day at Workday

2.2 Conducting a survey

Next, we had dived into finding statistics and data to validate our claim that the digital era deserves more attention, and to achieve that, the team decided to conduct a survey among software professionals and students of informatics and technology, computer science and computer engineering disciplines.

The survey was designed to collect data on whether they are working or studying, their role in the company (if currently working), their study background, programming experience, knowledge on sustainability, which sustainable practices they use in their daily life, their guess on total contribution of software industry to the carbon footprint, if they have ever implemented sustainable practices in their work tasks, as well as gathering their thoughts on whether they would be willing to invest some time to get educated about sustainability and if so, then via which mediums.

From figure 2 it can be stated that most of the participants have about average experience in programming. Figure 3 represents the statistics of whether they have ever implemented sustainable practices in their work tasks. Shockingly, about 74% of the participants have never implemented any sustainable practices in software development. However, it was not all dark and negative news,

because as Figure 4 portrays, we could see that 89% of the participants were willing to invest their time to learn more about sustainability in software development.

74 participants took part in the survey. The key findings of the survey are as follows:
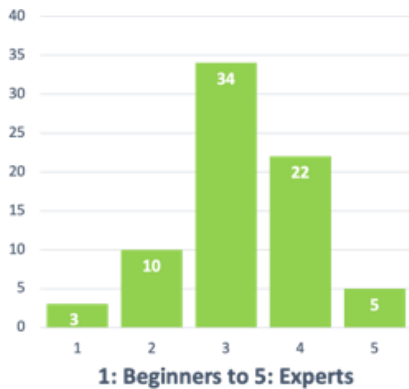

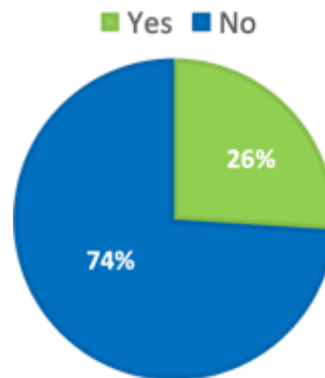
Figure 2 Experience in Programming

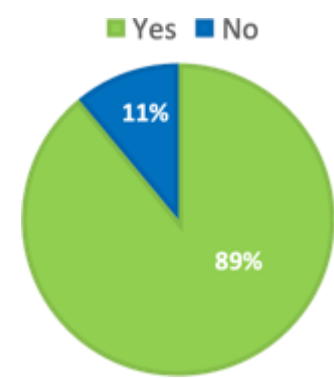*Figure 3 Ever Implemented sustainable practices*

Figure 4 Would you like to invest time to learn more about sustainability

Hence, after getting a concrete proof on our findings, we collectively decided to create a solution which covers three key issues. Respectively, lack of awareness regarding sustainability, lack of carbon footprint tools to measure the carbon emissions generated from the products, and lack of ideas to reduce the carbon footprints of existing products. That is why we decided to create an all-in-one awareness website course for software engineers, which empowers them with knowledge about sustainability, tools, and suggestions to further reduce the carbon emissions.

2.3 Weekly Check-in sessions

During this course, we had two kinds of meetings that were tremendously helpful as they not only guided us in the direction of our concept and how to get from several ideas to a tangible final product, but also about ways in which we could improve our concept and provide a better storytelling approach.

The first kind of meetings were held weekly with Veronica and Naim, which provided us a clear path to make constant progress in our project.

The second kind were held once weekly with both our mentors, in which we received feedback on our research and concept development.

Both types proved to be supportive and convenient for us to get our project to such satisfactory conclusion.

3. Product/ Concept

3.1 Why to build an awareness course?

As explained earlier, the online awareness course can be easily available to our target groups, which are: software firms, self-employed software professionals and students of the same stream. The major criticism we faced with our solution was: why our course is different than any other sources available on the internet? To answer that question, on one side, our course is the perfect combination of accurate information regarding sustainability, best available open software i.e., carbon footprint calculators and tips/suggestions to reduce the carbon footprint daily. On the other side, the other sources currently available are either provide only theoretical knowledge or only the theoretical steps on how does the footprint calculator work. Thus, our solution has a major advantage over other internet sources, providing a complete solution to three before mentioned problems in a single web-course.

3.2 Structure of the Course

We named our course as '*The Green Bang theory,*' which portrays the initiative taken in direction of the green code revolution. Our theory primarily consists of three main pillars, namely 1) Raising awareness 2) Footprint tools 3) Solutions.

Figure 5 SoftAware web course page
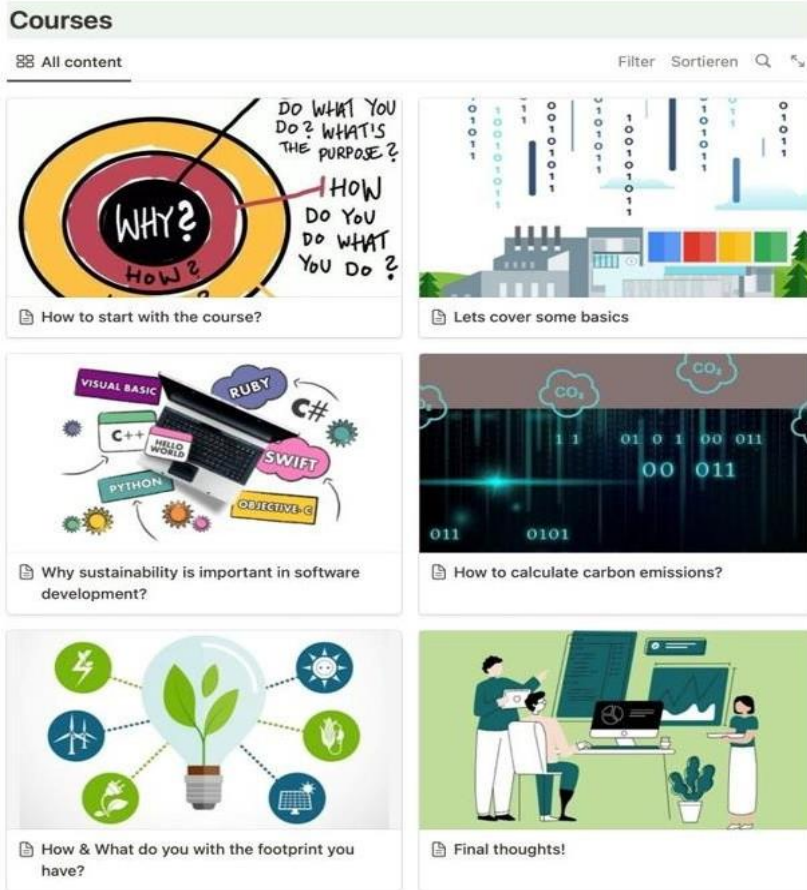
Figure 6 Green bang theory courses
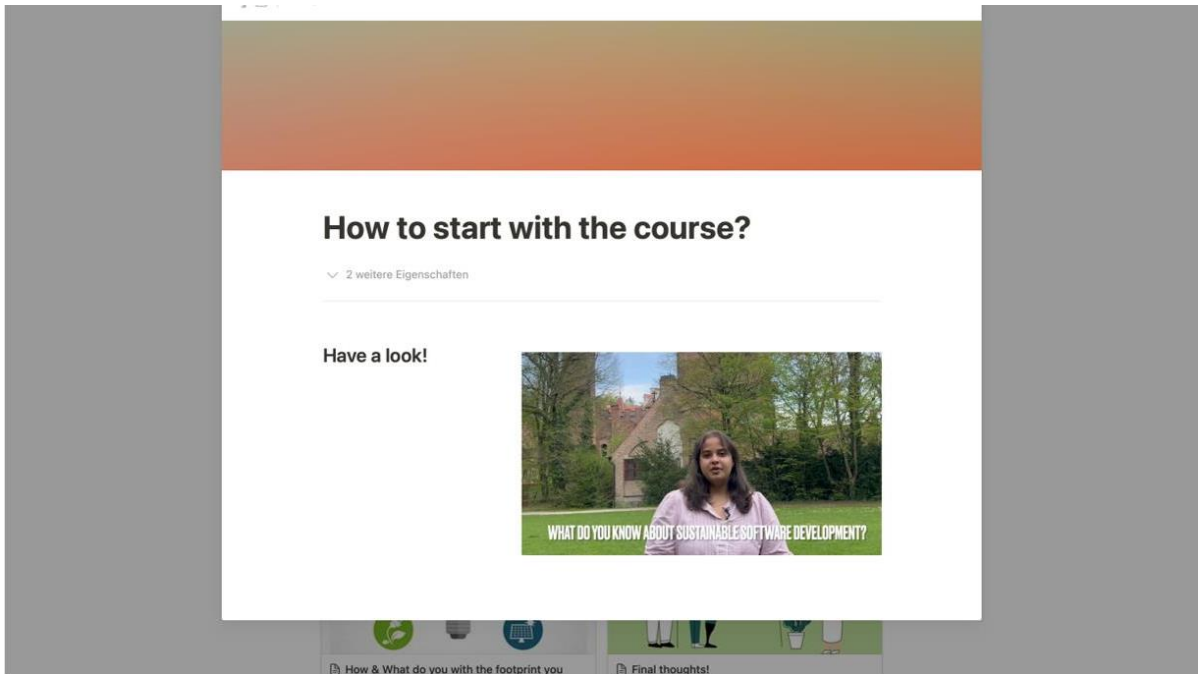
Figure 7 Insight of the video course
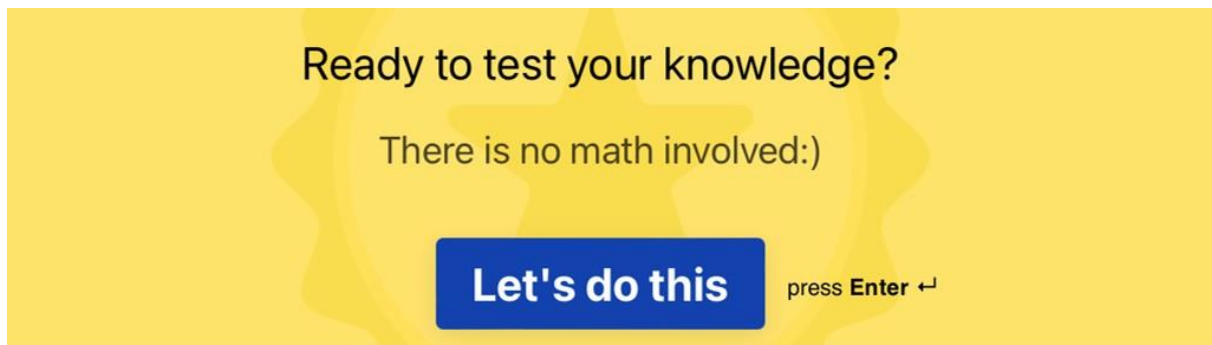
Figure 8 Quizzes after completion of the course

The figures 4 to 7 illustrate the overview structure of the web course. Starting with figure 4, this one gives an introduction on the topic and gets into the main issue which is, why sustainability is so crucial in the modern times? Moving on to the figure 5, these are the sub-modules of the web-course. Each module consists of Audio-visual illustration and in-depth knowledge on to the topic. Moreover, an insight of one of the video courses can be visible in the figure 6. Then, after going through all the courses, the participants may test their knowledge in all the quizzes available based on each module. Participants must score 60% or above in all the quizzes to successfully complete the course.

Figure 9 The Green Bang Certificate

Figure 10 Carbon net zero web course

This will reward you with a Green Bang Theory certificate. As Figure 8 shows, the first certificate was given to our first participant of the course and mentor, Eslam Shoaala.

Another important detail about our project is, while spreading the awareness on digital carbon footprint through our web-course, we also decided to be a flag bearer in this revolution. This means that all the video content and the web-course produced are carbon neutral, which implies that they are carbon net zero! This in turn indicates that our final product has no impact on the climate, as the carbon emissions produced are ZERO.

By doing this, we are hoping for our Green Bang Theory participants to get inspired and take the necessary footsteps in their own green code revolution journey.

Finally, the web course can be accessed from the link: https://denim-piccolo-7b5.notion.site/SoftAware-38d0d932cd63454f90f61ccbf8f59c9d

Let's get the Green Bang Theory started!

4.   The EuroTeQ Collider journey

Project Timeline

	A	B	C	D	E	F	
1	Date	Day	Time	Dealines	Project Task	Person assigned to/ attended by	Links
2	11.04.2023	Tuesday		Team Building Workshop/ Design Thinking	Research	Anu, Marie, Laura, Maitreyee, Krunal	
3	12.04.2023	Wednesday		Project Management Workshop	Research	Anu, Marie, Laura, Maitreyee, Krunal	
4	13.04.2023	Thursday		Self-study workshops	Research	Anu, Marie, Laura, Maitreyee, Krunal	
5	14.04.2023	Friday		Matlab-Course Creating Software Prototypes	Research	Anu	
6	15.04.2023	Saturday					
7	16.04.2023	Sunday					
8	17.04.2023	Monday					
9	18.04.2023	Tuesday					
10	19.04.2023	Wednesday					
11	20.04.2023	Thursday	15:00	First Team Meeting			
12	21.04.2023	Friday		First Meeting with Veronica			
13	22.04.2023	Saturday					
14	23.04.2023	Sunday					
15	24.04.2023	Monday			Team Catchup- Research and Planning ops	Anu, Marie, Laura, Maitreyee, Krunal	
16	25.04.2023	Tuesday	09:00	First Meeting with Mentors			
17	26.04.2023	Wednesday	16:30	In-Person Team Meeting	- Idea discussion, tasks, roles, preparation Update for Veronica		
18	27.04.2023	Thursday					
19	28.04.2023	Friday	08:20	Meeting with Veronica @8:20	Day at Workday	Anu, Marie,Maitreyee, Krunal	
20	29.04.2023	Saturday					
21	30.04.2023	Sunday					
22	01.05.2023	Monday	20:00		Call checkin	Anu, Marie, Laura, Maitreyee, Krunal	
23	02.05.2023	Tuesday			Survey		
24	03.05.2023	Wednesday			Survey		
25	04.05.2023	Thursday			Survey		
26	05.05.2023	Friday		Intensive Working Weekend	Producing content for the webcourse		
27	06.05.2023	Saturday		Intensive Working Weekend	Recording videos for course + writing content for notion page		
28	07.05.2023	Sunday		Intensive Working Weekend	Recording videos for course + writing content for notion page		
29	08.05.2023	Monday			Call with Eslam and Susanne		
30	09.05.2023	Tuesday			Design/ finalizing content		
31	10.05.2023	Wednesday			Design/ finalizing content		
32	11.05.2023	Thursday			Design/ finalizing content		
33	12.05.2023	Friday			Design/ finalizing content		

	Date	Day	Time	Dealines	Project Task	Person assigned to/ attended by	L
34	13.05.2023	Saturday			Design/ finalizing content		
35	14.05.2023	Sunday			Taking a break - TIMEOUT		
36	15.05.2023	Monday			Start with Presentation		
37	16.05.2023	Tuesday			Presentation		
38	17.05.2023	Wednesday			Presentation		
39	18.05.2023	Thursday			Finish Prototype & Presentation		
40	19.05.2023	Friday			Practicing and improving pitch		
41	20.05.2023	Saturday			Practicing and improving pitch		
42	21.05.2023	Sunday			Practicing and improving pitch		
43	22.05.2023	Monday		Final Presentation Test run			
44	23.05.2023	Tuesday			Receiving feedback from Naim/ Veronica/ Prof. Stefan Wurster		
45	24.05.2023	Wednesday			Presentation adjustments / Finalizing prototype		
46	25.05.2023	Thursday			Presentation adjustments / Finalizing prototype		
47	26.05.2023	Friday			Presentation adjustments / Finalizing prototype		
48	27.05.2023	Saturday			Presentation adjustments		
49	28.05.2023	Sunday			Presentation adjustments		
50	29.05.2023	Monday					
51	30.05.2023	Tuesday					
52	31.05.2023	Wednesday			Meeting at Workday with Eslam and Susanne		
53	01.06.2023	Thursday			Rehearsals Presentation at TUM campus		
54	02.06.2023	Friday		Final Presentation	WINNING!!!!	Everyone	
55	03.06.2023	Saturday			We Won!		
56	04.06.2023	Sunday					
57	05.06.2023	Monday					
58	06.06.2023	Tuesday			Presentation adjustments		
59	07.06.2023	Wednesday			Presentation adjustments		
60	08.06.2023	Thursday			Presentation adjustments		
61	09.06.2023	Friday					
62	10.06.2023	Saturday		Prague			
63	11.06.2023	Sunday		Prague			
64	12.06.2023	Monday		Prague	WE WON AGAIIIINN!!!		

Figure 11 Project Timeline

EuroTeQ weekend

Figure 12 EuroTeQ intensive work-weekend at burg Schwaneck

This section describes our journey through the entire course as the team SoftAware. The team navigated a meticulously planned project timeline, involving numerous team meetings and weekly check-in sessions with project leads and mentors. We highlighted our skills and expertise during the EuroTeQ intensive work-weekend at Burg Schwaneck, where we diligently crafted engaging video content and composed comprehensive written materials for the web course.

The team's hard work paid off as we received valuable feedback on the test presentations, allowing us to improve our delivery and refine the pitch. Our efforts culminated in a resounding triumph, as SoftAware emerged victorious in the energy block during the final presentations at the Technical University of Munich (TUM).

Our success continued to soar when we were announced as the winners in the "Ready to launch" category at the highly competitive and prestigious EuroTeQaThon, held at the Czech Technical University (CTU) in Prague. This incredible journey showcased SoftAware's unwavering commitment, teamwork, and exceptional skills by positioning us as trailblazers in the field.

EuroTeQ collider final presentation at TUM

Figure 13 Winner for the Energy Block - Final Presentations at TUM

EuroTeQaThon in Prague

Figure 14 Winner in Ready to Launch category – EuroTeQaThon at CTU, Prague

5.   Vision

In today's rapidly advancing world, where software development plays a pivotal role in shaping our future, it is crucial to foster sustainable practices within the industry. SoftAware, an innovative awareness course, aims to empower software developers by raising their awareness about the importance of implementing sustainable practices in their daily work life. By encouraging a culture of sustainability, SoftAware envisions a future where software development not only drives technological progress, but also ensures the well-being of our planet.

Understanding the Need

The software development industry has witnessed exponential growth in recent years, leading to an increased demand for efficient and scalable solutions. However, this growth comes at a cost, as it often leads to a significant environmental impact. As responsible global citizens, it is our collective responsibility to address this challenge and work towards sustainable development.

SoftAware- The Vision

SoftAware envisions a future where software developers are not only proficient in coding and creating innovative solutions but also deeply aware of the environmental consequence that their work can have. By integrating sustainable practices into their daily routines, developers can actively contribute to reducing carbon footprints, minimizing waste, and conserving resources. Thus, for the next steps, we would like to collaborate with software firms, and tech giants to introduce enforcement training of the Green Bang Theory. We would also like to cooperate with online learning platforms such as LinkedIn Learning, Coursera, and Udemy & Universities to reach a greater number of students and self-employed professionals.

Additionally, if we would continue our project, another priority would be to expand the course to include additional updates with modern technologies and research as well as incorporating our own carbon footprint calculator, which could be a rather useful tool for businesses. By making this effort, one of the main things that we are concerned with is creating an awareness course that is true to our own convictions. Besides, it should be designed efficiently such that it only has net zero digital footprint. We envision this as leading by example.

Key Objectives

- Raising Awareness: SoftAware aims to provide software developers with comprehensive knowledge about the environmental impact of software development. By understanding the lifecycle of software, from cradle to grave, developers will gain insights into potential areas where sustainability practices can be incorporated.
- Sustainable Software Development: SoftAware seeks to equip developers with the necessary tools and techniques to implement sustainable software development practices. This includes optimizing code efficiency, reducing energy consumption, and utilizing renewable resources wherever possible.
- Collaboration and Innovation: SoftAware recognizes the power of collaboration and encourages developers to come together to exchange ideas, best practices, and innovative solutions. Through workshops, forums, and networking events, SoftAware will create a platform for developers to share their experiences and learn from one another.

- Continuous Improvement: SoftAware acknowledges the dynamic nature of software development and the need for continuous improvement. The course will regularly update its curriculum to incorporate the latest trends, technologies, and research in sustainable software development.

Impact and Benefits

By participating in The Green bang Theory course, software developers will unlock numerous benefits and positively impact both their professional careers and the environment. They will gain:

- Knowledge: SoftAware equips developers with in-depth knowledge about sustainable software development, enabling them to make informed decisions that promote environmental responsibility.
- Competitive Advantage: Employers are increasingly prioritizing sustainability in their business strategies. The Green Bang Theory graduates will have a competitive advantage, as they will possess the skills and expertise necessary to develop software solutions aligned with sustainable goals.
- Industry Recognition: The Green Bang Theory certificate will serve as a recognized endorsement of a developer's commitment to sustainability, enhancing their professional reputation within the industry.
- Environmental Impact: The collective effort of SoftAware participants will lead to a significant reduction in the environmental footprint of software development. By implementing sustainable practices, developers will contribute to a cleaner, greener, and better future.

Conclusion

SoftAware envisions a future where software developers become catalysts for positive change, integrating sustainable practices into every line of code they write. By raising awareness, providing knowledge, and fostering collaboration, SoftAware empowers software developers to shape a more sustainable future for the industry. Together, let us embrace the transformative power of sustainable software development and pave the way for a better tomorrow.

References

[1] Computing industry CO2 emissions in the spotlight. (2009, January 15). Reuters: https://www.reuters.com/article/us-computing-carbon-emissions-idUSTRE50E5QO20090115

Eva   kern   et.al
Green software and green software engineering – definitions, measurements and quality
aspects,

[2] Podder, S., Burden, A., Singh, S. K., & Maruca, R. (2020, September 18). How Green Is Your Software? Harvard Business Review: https://hbr.org/2020/09/how-green-is-your-software

[3] ICT for Sustainability online: https://www.researchgate.net/publication/272086338_Green_software_and_green_software_engineering_-_definitions_measurements_and_quality_aspects Ayse Bener et. al Green Software, IEEE Computer Society

[4] The Green Software Foundation offers:
a. A training to many roles being in the software managing topic. Reach out for learning what fields are addressed: https://learn.greensoftware.foundation
b. Podcast: Calculating Software Emissions with Navveen Balani & Srini Rakhunathan: Calculating Software Emissions with Navveen Balani & Srini Rakhunathan: https://podcast.greensoftware.foundation/e/mn43klv8-the-week-in-greensoftware-calculating-software-emissions-with-navveen-balani-srini-rakhunathan

[5] Corporate Digital Responsibility: CDR - framework is the organisational policy of assuming responsibility in the age of digital transformation. In Sept. 23, for organizations there will be an open data-clean-up-project to reduce digital waste for the second time. For materials etc. reach out to De. Sara Elisa Kettner, CDR-Initiative. s.e.kettner@cdr-initiative.de What is CDR about: https://cdr-initiative.de/en/kodex

[6] Projekt on the UN-level: Summit for the Future/SDGs in 2024 In 2024, the UN will host a global "Summit for the Future". UN-Secretary-General António Guterres has proposed, to use this gathering of world leaders to adopt a "Global Digital Compact" (GDC). The GDC is aimed to give governments and non-state actors from civil society, the private sector, academia, and the technical community some guidelines how to move into the future of cyberspace: https://www.un.org/techenvoy/global-digital-compact

[7] Green Coding initiative: https://www.green-coding.berlin/

Appendix

Team member contribution to the report

Declaration of Authorship

We hereby declare that the project paper submitted is our own unaided work. All direct or indirect sources used are acknowledged as references.

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