StackSustain: a website for encouraging engagement in sustainability topics

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https://github.com/Guthax/stack_sustain/

We present StackSustain as a system to potentially fill the gap characterised by the lack of software that gamifies engagement in sustainability topics on StackOverflow, and related websites. In doing so, we attempt to promote sustainability and knowledge sharing in topics surrounding "green" software engineering.

To validate StackSustain, we manually check the correctness of the system for 12 user profiles and 15 recommended questions. In the specific profiles and questions that are checked, no errors are found. We thus find that it is in fact possible to extract sustainability-related information from StackExchange websites and present them in a gamified way to users.

Additionally, we highlight some limitations of the study, including the lack of automated unit tests, and lack of experiments testing the effectiveness of the gamification elements. This demonstrates a need for future work to both expand the scope of the system, and further test its value.

I. Introduction

The field of sustainable (green) software engineering has gained recognition as an emerging discipline, although it remains in its beginning stages [12]. Despite its growing importance, there is a notable lack of awareness of this evolving field. Sustainable software engineering holds significance as it prompts developers to consider the environmental impact of their projects.

Among the various online resources available to developers, StackExchange platforms like StackOverflow, SuperUser and ServerFault ([8], [9], [6]) are one of the most used sites for asking questions and getting answers related to technical problems [10]. Each question is categorized by a set of tags, which delineates its specific subject matter.

This paper introduces StackSustain, a gamification [7] tool designed to address the knowledge gap on sustainable software engineering by calculating a sustainability score based on a user's engagement with questions and answers which are defined by tags related to sustainable software engineering. By leveraging user activity on these topics, our tool offers a quantifiable measure of sustainability awareness and involvement within the developer community.

In the methodology, we will provide a general overview and technical details about StackSustain and why we chose the StackExchange platforms mentioned above. In validation, experiments are discussed which validate that the tool indeed displays an increasing score when a user is more active in sustainability topics. In the limitations sections, shortcomings of stacksustain are discussed. Future works provides possible continuations of this project. The conclusion wraps everything up.

II. Proposal

For this project we want to know if we can help users extract questions regarding sustainability on the different StackExchange platforms. As a possible solution for this problem, we propose a website called StackSustain [1].

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[1] https://github.com/Guthax/stack_sustain

The objective of StackSustain is to promote sustainability awareness and engagement within the developer community by providing a gamified platform that rewards users for their contributions to sustainability-related topics on StackExchange platforms. By encouraging users to ask and answer questions related to sustainability, StackSustain aims to foster a culture of environmental consciousness among developers and encourage sustainable practices in software engineering.

StackSustain is a web-based application that integrates with StackExchange platforms, including Stack-Overflow, SuperUser, and ServerFault, to assess users' engagement with sustainability topics. Users can input their account IDs for one or more of these platforms, and StackSustain retrieves their activity data to calculate a StackSustain score. This score reflects the user's level of involvement in sustainability discussions based on the questions they ask and answer, as well as their acceptance rate of answers. In the future, users will also be awarded badges which will further highlight their engagement regarding sustainability topics on these platforms. Being able to keep track of their progress might also be included in future versions.

In addition to the StackSustain score, the platform provides users with links to the sustainability questions they have asked and answered on each platform. It also offers recommended questions aimed at boosting their score, thereby encouraging continued participation in sustainability discussions.

Benefits:
- **Promoting Sustainability:** StackSustain motivates users to engage with sustainability topics, raising awareness and promoting environmentally responsible practices within the developer community.
- **Knowledge Sharing:** By highlighting sustainability-related questions and answers, StackSustain facilitates knowledge sharing and collaborative problem-solving on environmental issues.
- **Community Engagement:** The gamified nature of StackSustain encourages active participation and fosters a sense of community among users interested in sustainability, enhancing engagement and interaction within online forums.
- **Environmental Impact:** Through increased awareness and action on sustainability issues, StackSustain contributes to positive environmental outcomes by helping developers to make informed choices and adopt eco-friendly practices in software engineering.

Key Features:
- **StackSustain Score:** Calculates users' engagement with sustainability topics based on their activity on StackExchange platforms.
- **Question and Answer Links:** Provides users with links to the sustainability questions they have asked and answered on each platform.
- **Recommended Questions:** Suggests relevant sustainability questions to users to encourage further engagement and score improvement.
- **Integration with StackExchange:** Seamlessly integrates with StackOverflow, SuperUser, and Server-Fault to retrieve user activity data and compute the StackSustain score.

In conclusion, StackSustain represents a novel approach to promoting sustainability awareness and engagement within the developer community. By using the power of gamification and leveraging existing online platforms, StackSustain aims to drive positive environmental change by encouraging users to actively participate in sustainability discussions. With its user-friendly interface, StackSustain has the potential to become a valuable tool for promoting environmental consciousness and sustainable practices in software engineering.

III. Related Work and Background

We did not find existing solutions like StackSustain, emphasizing the novelty of our approach in the sustainability-focused online community domain. However, extensive research exists on gamification, behavior change for sustainability, and user behavior on platforms like StackOverflow.

Behavior change for sustainability is a multi-layered process influenced by numerous factors, including

social norms, policy frameworks, and individual motivations [11]. Research [5] emphasizes the importance of community involvement as a driver of sustainable behavior change. Our approach resonates with this research by prioritizing the cultivation of sustainable practices through encouraging the users to a more active involvement in online communities.

Gamification emerges as a powerful strategy for enhancing user engagement and driving behavioral change. Gamification refers to the integration of game-like elements, such as points, badges, and leaderboards, into non-game contexts to motivate and engage users. By incorporating these game mechanics, gamification taps into intrinsic motivations to encourage desired behaviors [2]. StackSustain employs gamification strategies to motivate sustainable actions among users, fostering a sense of achievement and progression as individuals contribute to environmental conservation efforts by asking and answering questions relevant to sustainability topics.

Insights drawn from platforms like StackOverflow offer valuable guidance for optimizing user satisfaction and fostering positive community dynamics within online forums. The paper 'The Ugly Side of Stack Overflow: An In-depth Exploration of the Social Dynamics of New Users' Engagement and Community Perception of Them' [4] illuminates the challenges faced by newcomers, such as difficulties in integrating into the community and negative perceptions of their contributions. It highlights the importance of addressing these challenges to foster a more inclusive and supportive environment. In response to these insights, StackSustain is about helping to bring sustainability questions to the foreground without considering for how long a user has been active in these online communities. Recommended questions for example do not differentiate if the questioner is a popular user on this platform or not.

In summary, StackSustain integrates insights from behavior change theories, gamification strategies, and insights of existing online platforms. Our solution seeks to cultivate an active and engaged community of sustainability enthusiasts committed to driving positive environmental change.

IV. Methodology

StackExchange encompasses numerous platforms, among which we have selected the following key ones:

- StackOverflow: Serving as **the** Q&A platform for programmers, StackOverflow stands as the largest community within the StackExchange network.
- SuperUser: As the second-largest platform, SuperUser caters more towards computer enthusiasts and power users.
- ServerFault: Mostly utilized by network and system administrators, ServerFault addresses issues related to server systems, an area crucial for energy consumption awareness.

Our application, StackSustain, leverages the StackExchange API [1] to access user questions and answers. StackExchange does **not** employ a unified account system across its platforms, so separate account IDs are required for each. Consequently, users are prompted to input their respective account IDs for each site (see Figure 1). Upon the user's request for their StackSustain score, the following process follows:

1) The backend component dispatches requests to each supported StackExchange platform via the API to retrieve the user's questions asked and answered.
2) Questions are filtered based on their relevance to the supported tags.
3) The StackSustain Score is computed as follows:
    Q = Questions asked by the user on each platform
    A = Questions answered by the user on each platform
    A_c = Answers by the user which are accepted as a solution
    S = StackSustain Score

$$S = Q + A + A_c \tag{1}$$

The following active tags are chosen to be related to sustainability:

- **energy:** Questions regarding energy consumption of hardware of different instruments such as CPUs, cell-phones etc.
- **power:** Questions related to power output.
- **electrical-power**
- **power-loss**
- **power-supply-unit:** Questions regarding power supply units - devices that convert mains AC to DC electricity for computer internal components [3]. Although the link is indirect, these questions also concern power usage

Furthermore, to future-proof the application, and encourage activity on the topic, the following tag is filtered on:

- **sustainability:** A broad tag which might encompass more theoretical questions about sustainability specifically, be that economic, environmental, social or technical sustainability

Additionally, users are presented with a list of suggested questions across all platforms aimed at raising awareness and encouraging engagement to enhance their StackSustain score and to raise engagement in sustainable software engineering(see Figure 1).
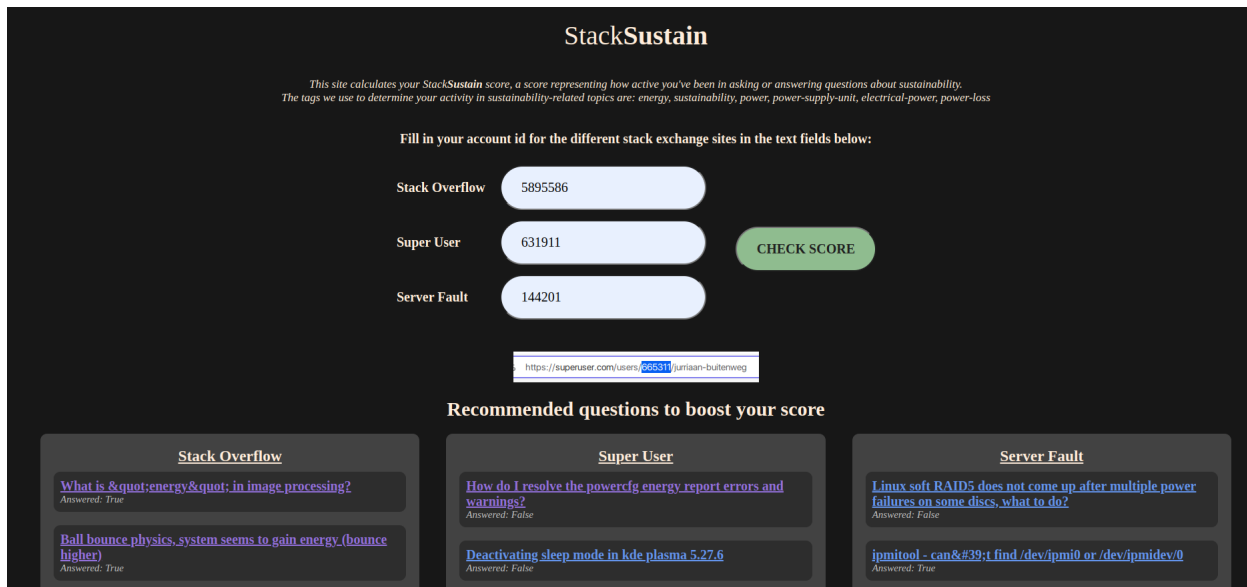

Figure 1. StackSustain homepage

V. Validation

In the validation phase, we conducted several tests to ensure the functionality and reliability of StackSustain. We tested various user scenarios for each of the three platforms: StackOverflow, SuperUser, and ServerFault. This included scenarios such as invalid users, users with a score of 0 for questions asked, users with a score of 0 for questions answered, users with a score greater than 0 for questions asked, as well as users with a score greater than 0 for questions answered. Additionally, we tested combinations of these scenarios to evaluate the system's robustness in handling different user inputs. The various test scenarios including the testing data used can be found in the appendix (table 1 and table 2).

We also checked the functionality of displayed links, verified if the questions retrieved indeed used the relevant sustainability tags, and manually confirmed the accuracy of the calculated scores by inspecting user profiles. For recommended questions, we examined the top five links for each platform to ensure they were functional, relevant to sustainability topics, and correctly identified as answered or unanswered.

4

Testing data, consisting of user profiles, was selected manually. We prioritized users with a moderate number of questions and answers to facilitate manual verification of the obtained scores.

Testing the obtained score was conducted by inputting user IDs and clicking on the "Check Score" button. Then verifying that the calculated score relates to the displayed results of the questions asked and answers given. And clicking the links to verify they work correctly and then checking whether the question uses the right tags and whether the user was indeed the questioner or the answerer depending on the result. We also manually compared the results obtained from StackSustain with the corresponding information on the platforms themselves to ensure consistency. For this we manually checked each profile and compared if there are questions or answers of the user that relate to the sustainability tags which were not shown on StackSustain. Also combinations of the test scenarios were checked to confirm that the results aligned with our expectations.

For recommended questions, we clicked on the provided links, verified that the questions used the sustainability tags, and confirmed the accuracy of their 'answered' status.

All tests passed successfully, indicating that the website functions as intended and fulfills its objectives effectively.

StackSustain effectively addresses the problem of extracting sustainability-related questions from StackExchange platforms. By providing users with a clear overview of their engagement with sustainability topics and suggesting relevant questions for further exploration, StackSustain promotes awareness and encourages active participation in sustainability discussions.

Despite the successful validation, it is important to acknowledge certain limitations. The tested users had a limited number of questions and answers, which may not fully represent typical user behavior. Additionally, we did not verify if there were sustainability-related questions that were not included in the recommended section, which could affect the completeness of our platform.

VI. Limitations

To gain an understanding of the representativeness of our validation, it is important to be aware of the limitations. This section will thus cover the factors that might have led to bias in the validation, as well as reasons for why our solution might not fully answer the research question.

To address the potential biases in our study, we should look at the validation procedure. First, it is important to note that we only manually checked 12 profiles and 15 recommended questions. Although this was due to the time-consuming nature of performing the manual checks, combined with the time limitations present, this is not a representative sample of the users or questions on StackOverflow, SuperUser, or ServerFault. This is compounded by the manual nature of our verification - there is a relatively high chance of human error, as opposed to if we had automated tests. Additionally, due to time limitations, we did not check that there were no questions with the relevant tags that were not displayed in the recommended questions section(s). Therefore, it is possible that bugs still exist in the score calculations, which goes against the findings of our validation.

Although our challenge was to create a application that encouraged engagement with sustainability topics, there are issues that might limit our ability to fully answer the question. Mainly, we did not ask developers about their opinion on the website, or test the effect of the website on their engagement. There is a chance that the way that the score is calculated and presented may lead to more surface-level engagement that can water down tags with duplicate or unnecessary questions. This means that, although we have tested for correctness of the system, we do not know how usable, or useful the system is to the challenge.

It is also important to remember that the website is not a full product, but more serves as a proof of concept for the challenge. This means that there are requirements that are not satisfied in this iteration of the website. However, the implementation of these requirements, such as having more complex StackSustain calculations that are impacted by factors such as the number of up/downvotes, would significantly affect the

results of our validation. There is a chance that the implementation of these features would compromise the correctness of the system.

Overall, despite having proven the validity of our StackSustain system, there are still limitations present in the study. These limitations highlight the importance of further work upon the system, as well as more thorough automatic testing and usability/engagement testing with real-life developers.

VII. Future Work

As mentioned previously, there are several limitations of the study, as well as unimplemented features that can be addressed in future work. This section will provide an overview of our recommendations about the work we believe would be beneficial to carry out if the topic is to be studied further.

As there are deficiencies present in the current validation of StackSustain, it could be useful to address them. To minimise the presence of human error in the verification of our system, automated unit tests could be created. In addition to giving a higher guarantee of the correctness of the system, this will also allow for safer refactoring, as it will be done with the knowledge that new features did not break old working ones. Furthermore, a usability test would be beneficial, as it could identify UI bugs and issues which could hinder the acceptance of the system. Finally, an investigation into the effectiveness of the gamification would need to be performed to determine whether the system positively influences developers engagement with sustainability topics within the StackExchange environment, as well as in their work and lives. Performing these more thorough validations will help in determining the value of StackSustain.

However, to perform these studies, it will also be important to finalise some of the features. For example, in the current state of the website, it must be run locally, as it is not hosted anywhere. This would both make validation with the aid of real developers more challenging, and make distributing the system to users more challenging. Thus, making the website run online will be a vital step in the future development of StackSustain.

Additionally, implementing a more robust scoring system, and adjusting it to user feedback, would also be an important step. This would involve research into the best ways to do this scoring, usability studies, and adjusting the queries to the StackExchange API to determine the "score" of questions and answers. However, it is important to note that developers that tackle this might face the same issues with the StackExchange API that we did, with long query times, throttles as well as misleading fields that sometimes have issues with linking to each other.

Finally, to ensure that the system is positively received by users, it will be important to perform some quality-of-life improvements for the system. The main issue here would be to tackle the fact that the system currently does not store any data about the user. While this makes our system lightweight (and perhaps more sustainable), the lack of visible progress to the user might hinder the effectiveness of the gamification elements in StackSustain. Since we do not want to force users to create an account to use the system as this is often considered cumbersome, other options for tracking progress can be considered. For example, giving the users an option to perhaps download their profile, and track their progress as such might incentivise them to revisit the website.

VIII. Conclusion

In conclusion, we have validated StackSustain as a viable system that can provide users of StackExchange websites with a score representing their engagement with sustainability-related topics. However, it is currently impossible to draw the link between this finding, and the statement that StackSustain can increase engagement in these topics. To identify the effect that StackSustain has on participation, more studies will need to be completed that investigate the usability of the system, and developers' responses to it. StackSustain thus currently serves as a proof of concept of a system that can gamify green software engineering in certain

developer spaces.

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Appendix

Link to our project on GitHub: https://github.com/Guthax/stack_sustain/

StackOverflow	SuperUser	ServerFault	Score	Asked	Answered	Description
123456789	-	-	0	-	-	Invalid User
-	123456789	-	0	-	-	Invalid User
-	-	123456789	0	-	-	Invalid User
123456789	123456789	123456789	0	-	-	Comb.: All invalid
12345	-	-	0	-	-	Valid User 0 Score
-	12345	-	0	-	-	Valid User 0 Score
-	-	123457	0	-	-	Valid User 0 Score
12345	12345	123457	0	-	-	Comb.: All valid: 0 Score
7209511	-	-	2	2	-	Valid User >0 Score asked
-	1869990	-	1	1	-	Valid User >0 Score asked
-	-	1071206	1	1	-	Valid User >0 Score asked
7209511	1869990	1071206	4	4	-	Comb.: All valid: >0 Score
123456789	12345	1071206	1	1	-	Comb.: Invalid, Valid 0, Valid >0
1544189	-	-	2	1	1	Valid User >0 Score answered
-	596313	-	2	-	2	Valid User >0 Score answered
-	-	1002205	1	-	1	Valid User >0 Score answered
1544189	596313	1002205	5	1	4	Comb.: All valid: >0 Score
123456789	12345	1002205	1	-	1	Comb.: Invalid, Valid 0, Valid >0
123456789	-	1002205	1	-	1	Comb.: Invalid, Empty, Valid >0

Table 1. Validation Data: User IDs

Question ID	Contains tags	Answered true/false: correct
StackOverflow		
76222588	true	true
77997965	true	true
3960588	true	true
76021688	true	true
4562801	true	true
SuperUser		
1632308	true	true
1800378	true	true
912679	true	true
354587	true	true
1612342	true	true
ServerFault		
1151703	true	true
480371	true	true
949818	true	true
561378	true	true
736068	true	true

Table 2. Validation Data: Recommended Questions (IDs)