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Sustainability-Related Gamified Design Science Approaches for Successful Value Creation

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ABSTRACT

The use of gamified designs has been gaining exponential research interest during the last decade, centered around user-centric designs aiming to persuade individuals to a successful individual behavioral change. In the focus of scientific interest are those, which lead to a maintained behavioral change led by intrinsic motivation. Such designs are at the center of attention in diverse sustainability-related topics as well (e.g., education, crowdsourcing, healthcare, individual wellbeing, eco-friendly behaviors, etc.). A focal point of such approaches lies in their rigorous conceptualization, for which design science offers detailed guidelines, resulting in successful artifacts, generated to deliver tailored solutions for users, providing value creation. The present paper aims to investigate, in what types of sustainability-related contexts are gamified approaches proposed as design science artifacts for successful value reaction. The goal of the paper is to identify and explore these research areas and hand a holistic overview about promising and innovative, applied approaches, conducted as design science artifacts. This goal is reached through a narrative synthesis method, searching and selecting papers at Scopus, Web of Science, and ACM Digital Library as databases, following the PRISMA 2020 Guidelines, interpreting N = 14 records. The results of this study deliver a structured summary about successfully gamified design science artifacts centered around value creation in pro-sustainability areas, offering a snapshot of the present standing of research in this applied domain of interest.

Keywords: Sustainability, Gamification, Design science

INTRODUCTION

In present times, characterized by our shared mission "to leave no one behind", sustainable development has been gaining momentum. This type of development, according to the Brundtland Report (1987) "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Report, 1987, p. 16). According to this report, states should construct systems for monitoring and progress evaluation towards achieving sustainable development. This is to be performed by adopting indicators that measure changes across economic, social and environmental dimensions. These three dimensions are widely adopted today as well. (Purvis et al., 2019).

The environmental dimension focuses on the proper management of scarce, or not renewable resources, focusing initially on natural resources during

the 1970s, later extended to complex systems, which support any types of living creatures on Earth. The economic dimension of sustainable development furthermore relates to the efficiency of company activities on the long run, while social sustainability refers to equal opportunities, reducing discrimination and poverty, respecting and embracing cultural differences. (Purvis et al., 2019).

According to Seaborn and Fels (2015), the importance of gamification in sustainability-related applications is notable, since they aim to support and encourage sustainable mechanisms, such as approaching resource efficiency, investing in recycling approaches and renewable energy forms. Therefore, gamification should purposefully focus on business processes and outcomes as well to modify user behavior and foster engagement in specific behavioral settings, focusing at different communities of interest, customers or employees. (AlMarshedi et al., 2015).

Gamification employs numerous game elements to evoke meaningful responses on the user side. (Purvis et al., 2019) A recent literature review conducted in the area of tailored gamification (Klock et al., 2020) standardized game elements from previous scientific literature with added descriptions to enhance further research.

Gamified solutions exist in diverse domains of sustainable development (e.g., Carter et al., 2022). However, there are numerous uncertainties in the proposed approaches; the theoretical basis of the generated solutions often lacks sufficient scientific grounding (i.e., applied solutions emerge without Kernel theories), the necessary methodological rigor and evaluation as well. (Deng & Ji, 2018).

According to Buchanan (1992), "wicked problems" may be defined as "a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing". (Buchanan, 1992, p. 15) Sustainable development is considered by numerous authors as such a wicked problem. (Pryshlakivsky & Searcy, 2013) Wicked problems arise in the scientific domain of Information Systems (IS) as well, wherein they indicate unstable requirements, ill-defined environmental contexts, complex interactions and among components, inherent flexibility to change processes and artifacts, depending on human cognitive (e.g., creativity) or social abilities (e.g., teamwork) to reach an effective solution. (A. Hevner & Chatterjee, 2010) Gamification has been emerging as a promising process to combat such problems. (Guillen Mandujano et al., 2021).

In the IS domain, traditions and development of Design Science Research (DSR) as been important and is increasing (Gregor & Hevner, 2013); this art of research paradigm focuses on theory-based problem solving by creating and evaluating artifacts designed to enable a transformation from the present to the desired one. (A. Hevner & Chatterjee, 2010; A. R. Hevner & Ram, 2004; March & Smith, 1995).

Gregor and Hevner (2013) proposed a publication schema for DSR studies, focused at the purpose and scope of the research, the identification of the classes of problems, and the relevance of the contribution to real-world practice.

Their schema consists of seven sections, including Introduction, Literature Review, Method, Artifact Description, Evaluation, Discussion and Conclusion. These sections were further discussed regarding their contents and their meaning in DSR context, serving as guidelines for conducting successful research practices under the umbrella of design science. Various topics of the Design Science Research (DSR) paradigm have been elaborated on during the past years (e.g., the design process itself (Kuechler & Vaishnavi, 2012), artifact type classifications (Offermann et al., 2010), or performed evaluation methods (Peffers et al., 2012)).

The demonstration of the DSR paradigm and its state of art have been emerging recently. The proliferation, quality and nature of DSR at IS conferences was the main topic of interest in the work of Induska and Recker (2010), based on a systematic literature review. Although the authors successfully demonstrate the prominence of design science, they also highlighted methodological weaknesses in the real-world contributions under the umbrella of design science. (Indulska & Recker, 2010).

In their 2011 study, Piirainen and Briggs discussed possible approaches to leverage design theory to improve the rigor and transparency of design science research. Their rendition was based on the work of Gregor and Jones (Gregor & Jones, 2007), in which the authors identified eight separate components of design theories: 1) purpose and scope; 2) constructs; 3) principles of form and function; 4) artifact mutability; 5) testable propositions; 6) justificatory knowledge (i.e., Kernel theories); 7) principles of implementation; and 8), an expository instantiation (Gregor & Jones, 2007). As Piirainen and Briggs concluded, design theory poses a valuable addition to the DSR framework, wherein it is an efficient tool in structuring both the design process and the product as well (Piirainen & Briggs, 2011). The importance, dominance and advocacy of design-oriented research is highlighted in the work of Heinrich and Riedl (2013), who explored this theme in the context of "Wirtschaftsinformatik" (Business Informatics or BI) as one if the major Information Systems (IS) communities, discussing the state of art with sixteen well-known BI scholars in terms of the genesis and development of Wirtschaftsinformatik, suggesting a " a theory-driven design approach". (Heinrich & Riedl, 2013, p. 34).

Kernel theories, originally defined in Walls et al. (1992), are "theories from natural science, social sciences and mathematics" (Walls et al., 1992, p. 41). Gregor and Hevner (2013) defined it as any descriptive theory, which informs about artifact construction, because of its ability to explain, why the design works. In this sense, justificatory knowledge is nearly synonymous to the definition of Kernel theories, however, the meaning of justificatory knowledge is broader, since it includes any knowledge, which informed the design process. (Gregor & Hevner, 2013).

The use of Kernel theories in design science is highly important, however, there are varying views in terms of their employment. Kuechler and Vaishnavi recommend the use of "design relevant explanatory/predictive theories" (DREPT) (Kuechler & Vaishnavi, 2012, p. 395), while other authors specify them as "applied behavioral theories" (Arazy et al., 2010, p. 461). Kernel theories govern the design requirements as a component of the design

theory, which governs the process through further meta-requirements and meta-design, ultimately reaching testable design product hypotheses for the design product. (Iivari, 2020).

Sustainability-oriented design science approaches have been emerging recent years, tapping into domains such as e-participation (Carter et al., 2022), business model development tools (Schoormann et al., 2021), eHealth (Gregório et al., 2021), to provide examples from the most recent research highlights. Since DS gains considerable momentum during recent years, including successful applications in sustainability-oriented areas, considering the promising possibility of gamification to support our journey in the wicked problem of sustainable development (Guillen Mandujano et al., 2021), this paper aims to enhance further explorations by providing a review of gamified artifact development, testing and evaluation under the umbrella of sustainable development through a narrative synthesis method.

METHOD

The present paper follows the PRISMA 2020 Guidelines for successful paper collection and selection to lead to a final set of publications, in which sustainability-oriented gamified solutions are discussed, which were developed under the research methodology of design science. Papers were collected at Scopus, Web of Science, and ACM Digital Library. Furthermore, Google Scholar was used to perform citation back- and forthtracking according to the suggestions of Webler and Webster. The initial search keywords and the roadmap of inclusion/exclusion criteria to reach the final set of papers are represented in the following paragraphs, aiming to introduce the steps of paper selection:

1. search terms and syntax used in the explored databases
    a. Scopus: (TITLE-ABS-KEY(gamif*) AND (TITLE-ABS-KEY("design science") OR TITLE-ABS-KEY(DSRM))) = 67 documents.
    b. Web of Science: (((TS=gamification)) AND TS=(sustainability) AND (TS=(design science)) OR TS=(DSRM)) = 126 documents.
    c. ACM Digital Library: [All: gamif*] AND [[All:"design science"] OR [All:"DSRM"]] = 45 documents.
2. Duplicate removal: After exporting the initial sets retrieved as search results (n = 238), N = 7 documents were removed as duplicates, resulting in 231 publications moving forward to the third step of the selection.
3. Reading titles and abstracts: Scopus 67-15 = 52; WoS 126-103= 23; ACM 45-24=21. As a result, 96 papers will be screened as full texts a well.
4. Eligibility criteria: after the screening of full texts, in the first steps, papers were included, if the core topic of the paper included a) a gamified solution, b) design science-based process operationalization, and c) sustainability-related implications. Those papers, where the design science research approach was not fully conducted, were excluded from the final set. Studies, wherein gamified elements are not specified, were

excluded from the sample as well. Furthermore, included were only papers previously published in a peer-reviewed scientific journals, or conference proceedings. Further inclusion criterion was the language of the publication, which had to be English, German, or Spanish. Lastly, only such papers were included in the final set, which discussed the publication schema proposed by Gregor and Hevner (2013) and reached the Evaluation phase of the generated artifact. After performing the screening, n = 14 publications were disseminated to be elements of the final set.

The present approach uses the narrative synthesis method, which is often performed, if a set of studies is heterogeneous in terms of methods, participants or data. (Lucas et al., 2007; Peters et al., 2020) Particular details of the final set of papers are described through computed frequencies. The narrative synthesis was performed through the classification of studies based on their area of research, design science approach, gamified approach, and their connection to sustainability.

Content analysis was used to identify and examine the papers of the final set regarding their design science approach. This type of analysis provides a systematic approach to classify text material according to predefined criteria (Downe-Wamboldt, 1992).

RESULTS

After the successful process of paper collection and selection, the present study analyzed N = 15 records that matched the above-proposed eligibility criteria. The descriptive characteristics of the chosen papers is to be found in the Appendix of this paper. In terms of publication dates, the papers date from 2015 (Helms et al., 2015) to 2021 (Souza et al., 2021; Thibault et al., 2021), with 8 publications stemming from 2020 (Aljabali et al., 2020; Almujally & Joy, 2020; De Troyer et al., 2020; Dincelli & Chengalur-Smith, 2020; Holzer et al., 2020; Silic & Lowry, 2020; van der Merwe et al., 2020; Wesseloh et al., 2020), one paper from 2019 (Park et al., 2019), and further two publications from 2017 (Marques et al., 2017; Morschheuser et al., 2017). The ratio of conference papers (N = 7) and journal articles (N = 8) is rather balanced. The citation count analysis showed that the most cited publication received N = 58 citations at the time of writing (Silic & Lowry, 2020), followed by the second most influential paper with N = 45 citations (Marques et al., 2017), while the third most cited paper received N = 37 citations (Morschheuser et al., 2017).

Aspects of Sustainability and Thematical Considerations

As the table in the appendix depicts, all three sustainability dimensions are represented in the focus of the evaluated papers; however, the ratios of papers in different dimensions are different. The highest ratio of papers (N = 8) strengthen the social dimension of sustainable development, mainly focusing on the 4th Sustainable Development Goal, quality education (Aljabali et al., 2020; Almujally & Joy, 2020; De Troyer et al., 2020; Helms et al., 2015; Park et al., 2019; Wesseloh et al., 2020), followed by papers entering to the

domain of the 3rd Sustainable Development Goal, thematically encompassing good health and wellbeing (Holzer et al., 2020; Marques et al., 2017). Papers in the economic dimension of sustainable development were mostly aiming to improve organizational and employee-related issues and conditions, linked therefore to the 8th SDG, namely decent work and economic growth (Dincelli & Chengalur-Smith, 2020; Morschheuser et al., 2017; Silic & Lowry, 2020; Souza et al., 2021) and one further publication discussing the enhancement of scientific process, communication and networking, relating therefore to the 17th Sustainable Development Goal, namely partnerships for the goal. The final set furthermore included one record related to environmental sustainable development, subjecting SDG 6, clean water and sanitation.

Further thematical explorations reveal that papers aiming to enhance quality education included diverse subdomains of this area, including personalized gamified learning models (Aljabali et al., 2020) and gamified e-learning systems (Park et al., 2019), knowledge management initiatives for knowledge sharing of teaching practices among university instructors (Almujally & Joy, 2020), setting specific focus on effective learning styles in mobile environments (De Troyer et al., 2020), class- or computer-based trainings enhancing engagement and motivation (Helms et al., 2015) and factual knowledge testing in a longitudinal manner (Wesseloh et al., 2020).

Records written under the umbrella of good health and wellbeing encompass approaches provided incentives for knowledge sharing and management in humanitarian contexts through the artifact testing at Doctors Without Borders (Holzer et al., 2020) and awareness raising regarding hand hygiene compliance to reduce hospital-acquired infections through the motivation for individual behavioral change in the case of hospital nurses (Marques et al., 2017).

Four records relate to the 8th Sustainable Development Goal (decent work and economic growth) in the economic dimension of sustainable development, tapping into areas such as information security and privacy enhancement through personalized training adventures (Dincelli & Chengalur-Smith, 2020), computer-supported cooperative work (CSCW) approach aiming to enhance knowledge sharing in innovation communities (Morschheuser et al., 2017). the improvement of employee phishing prevention and poorly received organizational internal security training (Silic & Lowry, 2020), and the transition between the "as-is" and "to-be" stages of the Business Process Management (BPM) life cycle to support organizational stability (Souza et al., 2021). One further record (Thibault et al., 2021) in the economic dimension of sustainable development – as mentioned before – analyzed the enhancement of communication and networking in scientific communities through the conduction of a gamified online international conference through an Alternate Reality Conference Game (Etsijä's Call) to build communal spirit, create a positive mood among the conference participants and provide a space for networking, therefore relating to Partnerships for the Goals (SDG 17).

Only one record considered the environmental dimension of sustainability by providing a gamified solution to raise citizen awareness in terms of water

quality issues and educate users during the process. The resulting artifact focused on oceanic plastic pollution. (van der Merwe et al., 2020).

Evaluation of Gamified Approaches

Critics of gamification often entail remarks noting that the present trends in use of gamified elements diverts to the direction of "pointification", concentrating mainly at points, badges and leaderboards, despite the vast opportunities in terms of existing game genres and types, offering diverse ideas and mechanics. (Thibault & Hamari, 2021) Despite these trends, also involving the scarcity of theoretical underpinnings behind the employment of the specified gamified elements, concentrating rather to single experimental designs, rarely discovering longitudinal effects or providing limited details for future researchers to replicate the original findings, the hereby analyzed publications strongly concentrated on both theoretical explanations behind the use of game elements, aiming to exploit as much promising elements as possible. Since design science research methodology strictly points out that artifact generation has to be based on diverse forms of explorations during the conceptualization process of the artifact in question, this sub area of gamification seems to focus strongly on the theory-based applicational design.

The evolution of the employed game elements is clearly traceable following the DSR process and their explored heterogeneity suggests that the authors followed the remarks and guidelines of previous research regarding gamification and the possible drawbacks of such applications, if poorly designed. Although badges, leaderboards and points are present in numerous approaches of the final set of papers (e.g., Aljabali et al., 2020; De Troyer et al., 2020; Helms et al., 2015; Marques et al., 2017; Wesseloh et al., 2020), the diversity of additionally employed game elements is considerable. Narrative designs (e.g., Thibault et al., 2021; van der Merwe et al., 2020), characters (e.g., Dincelli & Chengalur-Smith, 2020; van der Merwe et al., 2020), avatars (e.g., Marques et al., 2017; Silic & Lowry, 2020) were employed in multiple studies, along with time constraints (e.g., Souza et al., 2021; Wesseloh et al., 2020), various feedback types (e.g., Almujally & Joy, 2020; Helms et al., 2015; Marques et al., 2017), or life systems in diverse forms (e.g., Park et al., 2019; van der Merwe et al., 2020). The detailed list of game elements can be further examined at the table in the Appendix.

Evaluation of Design Science Approaches

The discussion of Kernel theories aimed to shed light on theories outside those of gamification (including self-determination theory or motivational theories). Such further theories included the knowledge-based theory (Almujally & Joy, 2020), online self-disclosure (OSD) (Dincelli & Chengalur-Smith, 2020), social independence theory (Morschheuser et al., 2017), or the information and decision theory (Souza et al., 2021).

The artifact evaluations of the analyzed papers concluded positive results and successfully demonstrated the desired effects of the proposed artifacts. However, replications should be highly recommended to approach the

generalizability of these results in a comparative manner. Furthermore, longitudinal effects of the levels of possible knowledge retention would be essential to see the long term effects of the generated artifacts.

The implications of the evaluations shed light to numerous instances, which may serve as focus of future research. Such remarks include that receiving too many negative comments may cause the feeling of detachment from the community, while high ratings encourage more user contributions (Almujally & Joy, 2020). During the conceptualization of the artifact, Helms and colleagues developed a new taxonomy (Educational Game Element Database) to represent the effects of each analyzed gamified element on learning. (Helms et al., 2015).

Furthermore, the inclusion of ambient artistic objects enhanced user engagement; this gamified element may be considered as the relatively rarely employed one, encouraging more research regarding its use (Holzer et al., 2020). A further interesting implication of this study was that feedback gamification had a positive effect on the contribution of altruistic individuals; however, no differences were present in the control group (Holzer et al., 2020).

Valuable implications were drawn from the paper focusing on the hand hygiene of nurses to avoid hospital-based infections; nurses expressed their joy for the unique opportunity to receive feedback regarding their hand hygiene habits, however, the authors concluded that the present standing of indoor location technologies are still not mature enough to be readily applied under the analyzed circumstances (Marques et al., 2017).

CONCLUSION

The present paper aimed to analyze the domain of sustainability-oriented, gamified approaches conducted under the umbrella of design science research. The goal of this paper was to thematically analyze these approaches, discover the diversity of domains of interests, taking into account the manner of gamification and selected aspects of their performed design science research. After a successful literature search and paper selection following the PRISMA Guidelines, this paper embarked on a journey of narrative synthesis to see forms and approaches of value creation under the light of sustainable development.

The discussion of dimensions of sustainable development revealed that most studies concentrated on the social dimension, encompassing studies in the area of education and health, followed by the economic dimension entailing domains related to decent work and economic growth. Although there is a wide array of studies discussing gamified solutions related to sustainability, papers conducted using design science research did not depict such diversity.

The use of game elements revealed promising approaches in terms of theory-based, successfully employed elements, which showed great diversity. This trend may also show that previous criticisms of the conceptualization of gamified elements is in the focus of the scientific community. Design science research methodology and its rigorous process criteria are therefore

successful in guiding research in this regard, urging researchers to not to leave a stone unturned during the conceptualization process.

The analyzed papers provided positive results for their problem statements and research questions/hypotheses, which is in line with previous considerations regarding the benefit of design science-based approaches, which consider implications before the artifact release, thereby reducing the chance for possible, unforeseen drawbacks after the publication of the artifact.

The present paper is limited to studies, wherein the design science research process already reached the evaluation phase of the artifact. Therefore, pure theoretical considerations and conceptualizations are missing from the final set of papers. Furthermore, while the paper tapped into the theoretical underpinnings of the selected papers by discussing their Kernel theories and the implications of their artifact evaluations, other points of comparisons regarding the DS approach were not discussed as a result of space constraints.

Further research should therefore provide a detailed comparison of such articles, including the types of discussed knowledge, methods of evaluation and types of artifacts. Furthermore, by taking a deeper look into those papers, which entail only theoretical conceptualization, future research may shed light to their discussed sustainable development dimensions and conjoining SDGs to see possible similarities or differences in the discussed domains in comparison to this paper's results. Lastly, the art of gamification in this subdomain depicts detailed, theoretically mature and diverse considerations; the question poses itself, whether such developments in gamified element conceptualization and rigor can be discovered in other subdomains of sustainable development. By taking these future endeavors, research will greatly contribute to applied solutions under our common, shared mission "to leave no one behind", while taking a step closer in our journey to "make gamification punk again" (Thibault & Hamari, 2021, p. 14).

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APPENDIX

Table A1. Summary of paper characteristics discussed in the study.

Author(s), Date	Type of Contribution	Name of the proceedings / journal	Cit. count	Sustainability dimension	Gamified elements
(Aljabali et al., 2020)	journal article	Journal of Theoretical and Applied Information Technology	0	social	badges, levels, challenges, progress bar, points, avatars, goals, customization, ranking, leaderboard
(Almujally & Joy, 2020)	conference paper	COMPSAC 2020	1	social	status ranking, vote-up ranking, written feedback
(De Troyer et al., 2020)	journal article	Information	5	social	leaderboard, feedback, points, challenges, customization, notifications, quizzes, riddles,
(Dincelli & Chengalur-Smith, 2020)	journal article	European Journal of Information Systems	10	economic	storyline, discovery, characters, progression, curiosity, feedback, interaction, rules, control, fun
(Helms et al., 2015)	conference paper	PACIS 2015	25	social	progression (levels, quests, story line, objectives, discovery, problem solving, characters, curiosity), rewards (points, badges, resources/virtual goods, win states), rules (general rules, time constraints, chance), social (fellowship/teams, fantasy), competition (leaderboard, conflict/competitions), challenge (challenge, boss fights), communication (feedback, interaction), general (control, fun, play)
(Holzer et al., 2020)	journal article	European Journal of Information Systems	16	social	points, levels, playful representation, ambient object
(Marques et al., 2017)	journal article	BMC Medical Informatics and Decision Making	45	social	1st instantiation: avatar, real-time feedback, competition (scores), win state; 2nd instantiation: level, avatar, name, current score, progress bar for visual feedback;

Table A1. Continued.

Author(s), Date	Type of Contribution	Name of the proceedings / journal	Cit. count	Sustainability dimension	Gamified elements
(Morschheuser et al., 2017)	conference paper	CSCW '17: Computer Supported Cooperative Work and Social Computing	37	economic	increased level difficulty; leaderboard; badges; virtual currency; rules visual objects; visual scenes; challenges; shared goals; special abilities; instant positive performance feedback; cooperative graphic as visualization
(Park et al., 2019)	journal article	Computers & Education	25	social	challenges; animations; quizzes; experience points; levels; life system; increasing level difficulty with "boss" question in the end; immediate feedback; dashboard for feedback on user performance; showcase image; avatar evolution; content unlocking
(Silic & Lowry, 2020)	journal article	Journal of Management Information Systems	58	economic	avatar, game master, points, levels, notifications, achievements, leaderboards, quizzes, additional incentives, visual appearance
(Souza et al., 2021)	journal article	Benchmarking: An International Journal	0	economic	challenges, collaboration, visual appearance, feedback, checkpoints, progress assessment, time constraints,
(Thibault et al., 2021)	conference paper	GamiFIN 2021	0	economic	narrative design, protagonist, chat, quests, hidden object seeking, puzzle
(van der Merwe et al., 2020)	conference paper	AMCIS 2020	0	environmental	scenarios, fact panels, quizzes, time constraints, visual appearance, health bar and life system, quizzes, characters, narrative,
(Wesseloh et al., 2020)	conference paper	ECRM 2020	1	social	question sessions, time constraints, difficulty, badges, rankings, narrative, characters, avatars, avatar characteristics; life system, damage system, direct feedback, quizzes, points, leaderboard, streaks, quests, collaboration, levels, statistics, lobby