

12 years of research into behavior change support systems

Harri Oinas-Kukkonen¹, Sharon Nabwire¹, Elena Vlahu-Gjorgievska² and Sriram Iyengar³

¹ *University of Oulu, Finland*

² *University of Wollongong, Australia*

³ *University of Arizona, USA*

Abstract

Behavior Change Support Systems (BCSS) have shown promising results in motivating and supporting individuals to change their behaviors and attitudes toward improved health or other areas or adopt new ones. This paper discusses research contributions related to the design and development of BCSS presented in the workshop under the same name in conjunction with the annual series of the International Conference on Persuasive Technology. The contributions of both previous research and the latest edition of the workshop are discussed in this paper.

Keywords

Behavior change support systems, persuasive technology

1. Introduction

Persuasive technology covers the intersection of natural, social, and other scientific disciplines, requiring multidisciplinary design, implementation, and assessment approaches [32]. Research is needed to explore the transformative nature of technologies in modifying behaviors and systematically monitoring the efficacy and consequences of digital interventions. Using information technologies as persuasive agents has the potential to shed light on the underlying elements of persuasion, exerting an impact on attitudes and behaviors. Researchers have gained interest in social dimensions and the downsides of persuasion through these technologies.

Over the past decade, many persuasive applications have emerged to promote positive behavior changes across domains, such as health and well-being, sustainable energy practices, educational concepts, and marketing strategies [14]. Moreover, advances in technology have created intelligent, virtual, and persuasive environments that offer diverse sensory cues and psychophysiological feedback, fostering personal transformation through heightened emotional, social, and physical engagements.

The Behavior Change Support Systems (BCSS) workshop centers on developing systems that facilitate and reinforce behavior change initiatives among individuals or collectives. At its core, the workshop represents a profoundly multidisciplinary ethos underscored by its commitment to designing and implementing strategies and systems conducive to behavior change across diverse domains.

This workshop unites researchers, practitioners, and experts from various scientific disciplines, including information systems, information sciences, human-computer interaction, industrial design, psychology, and medicine. As a scholarly forum, the event adopted a conference format to facilitate the presentation, discussion, and deliberation of research findings and the foundational tenets of persuasive technology.

BCSS 2024: The 12th International Workshop on Behavior Change Support Systems, April 10, 2024, Wollongong, Australia.



© 2024 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

2. Background

The workshop series focuses on developing information systems that facilitate and promote behavioral change and it acknowledges the multidisciplinary nature of designing and implementing strategies for behavioral change and the corresponding information systems, services, and software. To date, 12 editions of the BCSS workshop have been held successfully in conjunction with the Persuasive Technology Conference. Since its inception in Sydney, Australia, in 2013, 84 peer-reviewed papers have been published in the workshop proceedings, attracting 211 authors of these papers from academia and industry in 25 countries to share their research on various aspects of behavior change support systems. Each year, the workshop has typically hosted more than 20 authors who present their research findings.

3. Highlights of previous research

For this paper, we reviewed the publications in the workshop series to gain a broad picture of proceedings to date. This was an integrative review [50], a comprehensive literature review synthesizing research studies to better understand the research area. The papers presented in the first workshop in 2013 focused on the abstraction, implementation, and evaluation of Behavior Change Support Systems (BCSS), and this has continued with more research focusing on the evaluation of BCSS's effectiveness.

3.1. Keyword frequency

Figure 1 shows the top 20 most frequently occurring keywords in the BCSS workshop publications. Not surprisingly, *Behavior Change Support Systems*, *Persuasive Technology*, *Persuasive Systems Design*, and *Behavior Change* were the most used since they are a central focus of the workshop. Keywords such as *Gamification* and *Serious gaming*, *Self-tracking*, *Social Influence*, and *Self-management* highlight some of the strategies and elements used to induce behavioral change. *Health*, *eHealth*, and *mHealth* highlight the dominance of the health domain in behavior change research in the workshop series.

3.2. Application domains

Over the years, several application domains have been highlighted through the BCSS proceedings, including health and well-being, marketing, and environmental sustainability. However, the health and well-being domain continues to generate significant interest with various applications in weight management [15, 51], physical activity [30], cardiovascular postoperative care [38], asthma management [1, 22], and cancer [46]. Physical therapy-based methods and applications are widely used in healthcare. Another area of health research has focused on public and mental health [25, 26]. For example, Langrial et al. [26] investigated the impact of social behavior change messages on people in response to the COVID-19 pandemic. Studies on mental health have involved identifying persuasive features for virtual coaches in mental health interventions for issues such as depression and anxiety [39] and stress management [20, 33]. Oyebode et al. [33] explored the persuasive strategies utilized in 100 mental health apps.

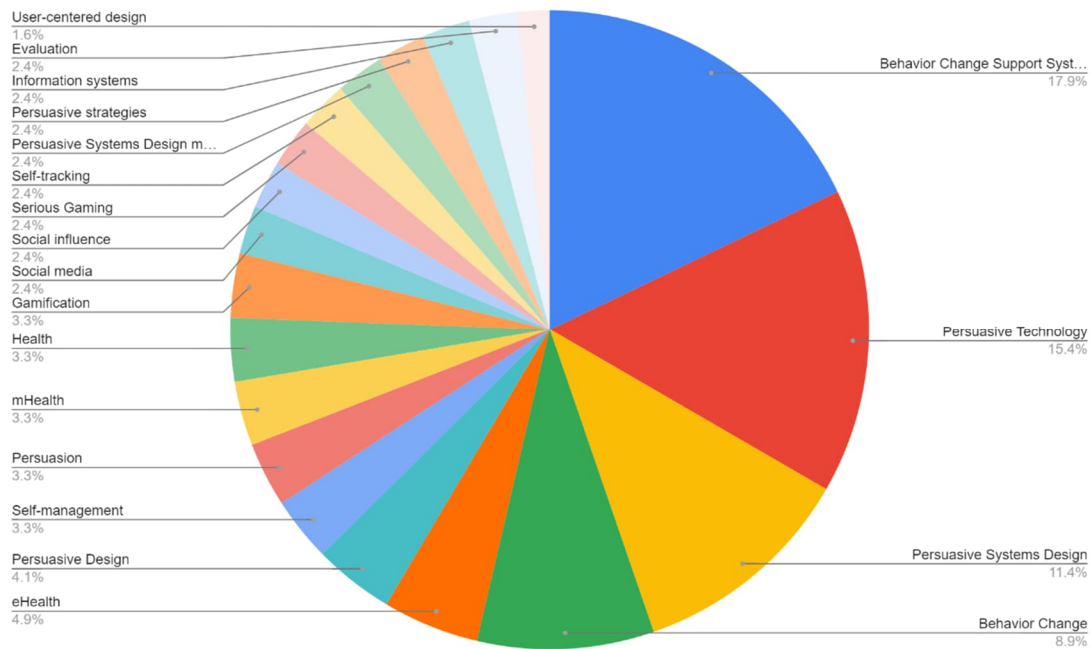


Figure 1: Keyword Frequency

Lifestyle interventions or study areas include garbage disposal behavior [34], physical activity [16], secure smartphone behavior[10], time-keeping skills [42], environmental sustainability [36] and digital addiction [18]. For instance, Ozono et al. [34] proposed and evaluated an intervention method for taking out rubbish. Using visual cues and inducements, they assessed the impact of the intervention on behavior attitudes and personality traits. To address the issue of inadequate water intake among children, Bootsma and Ciocarlan used persuasive strategies and interactive storytelling techniques to improve children’s knowledge and foster a positive attitude towards drinking water[3].

Studies on environmental sustainability have included providing personalized and tailored support to travelers to promote environmentally sustainable transportation practices [28] and using persuasive strategies in ambient energy displays to lower energy consumption in private households [23]. Paraschivoiu et al. provide insights into the design of sustainable platforms that encourage behavior change related to climate change on a city level by using a user-centric approach [36].

Other studies have focused on marketing [2, 17], cyber security [5, 10, 19], and recommender systems [11, 45] as well as BCSS in education and learning, such as embedding persuasive technology into existing curricula [31], and designing educational tools for individuals with intellectual disabilities [48]. Some research has also focused on conceptual design [7], user experience[21], implementation of behavior change [24], and behavioral psychology [9] without narrowing it down to an application domain. These proceedings highlight that BCSS research application areas contribute to fields also outside of health and well-being.

3.3. Applied technologies

Mobile apps have been at the center of BCSS research owing to the proliferation of smartphones. However, as technology continues to evolve, we are starting to see that research utilizes different technologies, such as virtual reality, sensors, and blockchain, in behavior change research. For instance, Sharma et al. [40] utilized a sensor-based information communication platform to gain insights into the information communication needs of informal caregivers. Paajala et al. [35] attempted to define how blockchain technologies can be utilized to develop persuasive systems, highlighting the benefits and challenges of using blockchain in BCSS. Using a body-centric

approach, Klaassen et al. [22] used a virtual reality-controlled environment integrated with therapy sessions for people with substance abuse disorders and intellectual disabilities to trigger the application of self-control strategies. The effect of social media on behavior change interventions was demonstrated by Tikka et al. [43], who used Twitter to deliver interventions and receive peer support. Chow et al. [7] suggest utilizing embedded persuasive systems to break habitual routines and generate effective sensorimotor experiences.

3.4. Research approaches

Various research methods have been utilized, including systematic reviews, mixed methods research, qualitative studies, natural language processing, case studies, experimental designs, and heuristic evaluations. Earlier research focused more on the design and development of BCSS. As we progress, we see more research focusing on evaluating their effectiveness. The Persuasive Systems Design (PSD) model offers a methodical and categorical assessment of persuasive information systems and has been employed to examine and assess the persuasive characteristics of BCSS. The model remains central to BCSS research as a methodological, conceptual, and theoretical basis for determining each situation's suitability and distinct demands. It has also been applied as a guide for the design and development of BCSS.

4. Most recent contributions

The 2024 edition of the workshop was a hybrid event showcasing distinguished research papers on designing and implementing BCSS domains of health and well-being, social media, sports, and recreation and design. These studies covered various contexts of BCSS and explored topics of user experience, design guidelines, online influence, and the cost of BCSS development.

In their study, Vlahu-Gjorgievska et al. [47] explored surfers' needs and perceptions of safe surfing apps. In-depth interviews with 13 surfers yielded insights into the key functionalities and visual aspects required to create successful and safe surfing applications. Their study identified three main themes: application features, content, and design. This study highlights the significance of up-to-date weather and surfing conditions and beginner-friendly instructional materials as surfers' main information needs. Additionally, the study emphasizes the importance of app design in encouraging user interaction and how implementing personalized notifications is crucial for raising awareness of safety issues. They later applied persuasive principles to these findings using the Persuasive System Design model [32], which allows the integration of social facilitation, personalization, and reminders into safety surfing apps. Ultimately, this study highlights how revolutionary safe-surfing applications can improve surfing experiences and encourage a responsible and safe-surfing culture.

Cao et al. [6] recognize the impact of prenatal and postpartum care on maternal and child health. To address the current shortage of healthcare services that cater to the needs of expectant and nursing mothers, the team has developed a mobile application called TEKUTECH. Based on the Information-Motivation-Behavioral Skills model [8], the app guided pregnant and nursing mothers for 20–23 weeks. Using sixty-five participants, the study evaluated the app's effectiveness in promoting positive behavior changes, including walking behavior, sun exposure, and nutritional intake. This paper describes the app's features, the experiment's overall design, the collected data, and the participant's feedback on the app.

The paper by Guadagno et al. [12] investigates corporate communication practices on social media and focuses on how these practices influence customers' intentions to engage with a brand. Through two comprehensive studies, the authors analyzed participants' inclination to patronize specific restaurant chains after interacting with the brand's Twitter account. The analysis considered various response strategies from the online social influence model [13] employed by corporate Twitter accounts, including direct replies, retweets, and non-responses. Their findings in both studies confirmed their prediction that reciprocity norms would lead individuals to prefer

restaurants that engage in their tweets. This demonstrates that participants had stronger intentions to support a restaurant after the Twitter interaction.

Li and Tajario [27] studied the persuasive system design principles for pandemics. Through a workshop approach, 16 participants accessed the comprehensibility of persuasive system design principles. They highlight the challenging PSD principles from the designer's perspective. The findings showed that some PSD principles necessitate context-specific interpretation for effective integration into health app development.

To understand the cost of developing persuasion in health behavior change support systems (HBCSS), Nabwire and Oinas-Kukkonen [29] explore the perceived cost of developing persuasive features in HBCSS. Using in-depth interviews with experts and the weighted sum model (WSM) [44], the team estimated the perceived cost of developing persuasion in a hypothetical weight management app using three parameters: expertise, effort, and cost. The results highlight that dialogue and credibility support features may require fewer financial resources than social and primary support features.

Peres and Campos [37] explore the challenges faced by informal caregivers and seek to understand the effects of watching nature videos on informal caregivers' emotional well-being. More specifically, this study explores the potential benefits of watching nature videos to increase valence and positive effects without leaving home. Using Self-Assessment Manikins (SAM) [4] and Positive and Negative Affect Schedule (PANAS) [49] scales, this study compared the effects of nature videos between informal caregivers and non-caregivers. Their findings showed that watching nature videos positively affected informal caregivers' well-being.

McGowan et al. [28] focused on the transformative potential of persuasive system design and examined its impact on mobile health applications. The study applied a multiphase experimental design, developing and evaluating 25 mobile health app screens using PSD principles. The process included rigorous prototyping, expert review, and iterative design to ensure the effective incorporation of persuasive elements tailored to diverse user groups. Their findings underscore the effectiveness of combining primary task support and dialogue support in mobile health apps to maximize user engagement.

5. Conclusion

Since the BCSS workshop series's inception, many studies and perspectives have been presented regarding behavior change support systems. These studies reveal the advancements and challenges in the BCSS and persuasive technology, highlighting their potential to motivate behavior changes across multiple domains. Although short-term interventions have demonstrated success in encouraging physical activity and other health-related behaviors, there is a growing focus on addressing chronic conditions, such as diabetes and obesity [12], and long-term effects [41]. The most recent contributions provide unique insights into how BCSS research can help shape and influence people's behaviors, from exploring its application in social media corporate practices to persuasive principles in different health application development. A detailed systematic review and text analysis of the publications could provide additional insights and trends into BCSS research.

References

- [1] N. Almutairi, E. Vlahu-Gjorgievska, K. Than Win, Asthma management Application for Consumers: Nudging as a feature. In: 7th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2019).
- [2] F. Bennett, W. Lewis, Project-Machete: a Weapon to Cut Through the Amazon(.ca). In: 9th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2021).
- [3] R.E. Bootsma, A. Ciocarlan, Persuasive technology design for children: Changing behaviours, improving knowledge, and encouraging positive attitudes towards drinking

- water. In: 11th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2023).
- [4] M.M. Bradley, P.J. Lang, Measuring Emotion: The self-assessment manikin and the semantic differential. (1994).
 - [5] M. Busch, S. Patil, G. Regal, C. Hochleitner, P. Fröhlich, M.Tscheligi, Persuasive Information Security A Behavior Change Support System to Help Employees Protect Organizational Information Security. In: 3rd International Workshop on Behavior Change Support Systems. CEUR-WS.org (2015).
 - [6] L. Cao, M. Taya, Y. Sakamoto, Y. Honda, S. Hukuda, Y. Sato et al., Health-related behavior changes using IoHT for pregnant and postpartum women: From the Be-TWINKLE study. In: 12th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2024).
 - [7] K.K.N. Chow, B.D. Leong, B.Y.H. Lee, K. Wai, M.Siu, Animating Embedded Behavior Change Support Systems in Physical Environments. In: 7th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2019).
 - [8] D.F. Fisher, A.W. Fisher, A.P. Shuper, The information-motivation-behavioral skills model of hiv preventive behavior. Emerging theories in health promotion practice and research. Presented at the (2009).
 - [9] D. De Franco, A. Pease, Designing Behaviour Change Support Systems for Behaviour Transformation. In: 7th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2019).
 - [10] A. Ganesh, C. Ndulue, R. Orji, The Design and Development of Mobile Game to Promote Secure Smartphone Behaviour. In: 9th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2021).
 - [11] S. Gkika, G. Lekakos, The persuasive role of Explanations in Recommender Systems. In: 2nd International Workshop on Behavior Change Support Systems. p. 59 CEUR-WS.org (2014).
 - [12] R.E.Guadagno, A. Sardos, A. Kimbrough, If You Reply to Me, I Will Buy from You: A Social Influence Examination of Reciprocity on Twitter. In: 12th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2024).
 - [13] R.E. Guadagno, R.B. Cialdini, Online Persuasion and Compliance: Social Influence on the Internet and beyond. (2009).
 - [14] S. Haque, S. Iyengar, P. Karppinen, L. Van Gemert-Pijnen, H. Oinas-Kukkonen, What do we know about behavior change support systems after a decade of annual meetings? (2023).
 - [15] G. Huizing, Multi-Perspective Persuasion by a Council of Virtual Coaches. In: 8th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2020).
 - [16] N. Hungerländer, Using persuasive features to promote physical activity for older employees-Report from the AgeWell project. In: 10th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2022).
 - [17] Y. Kashimoto, J. Hyry, M. Taya, H. Ishizuka, A. Kobayashi, Applying In-depth Interview to Explore the Use of Electronic Coupons and Customer Behavior Change. In: International Workshop on Behavior Change Support Systems (BCSS). CEUR-WS.org (2013).
 - [18] Y. Kashimoto, J. Hyry, P. Karppinen, H. Oinas-Kukkonen, M. Taya, C. Ono, Preliminary study on the smartphone zombie phenomenon by utilising a monitoring application. In: 8th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2020).
 - [19] R.H.P. Kegel, R.J. Wieringa, Behavior Change Support Systems for Privacy and Security. In: 3rd International Workshop on Behavior Change Support Systems. CEUR-WS.org (2015).
 - [20] M. Kekkonen, H. Oinas-Kukkonen, Doctoral Students' Battle of Stress-Designing BCSS to Help Them Win the Battle: Searching for Design Improvements via Workshops with End-Users. In: 9th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2021).

- [21] M. Kekkonen, H. Oinas-Kukkonen, Social Comparison in Behavior Change Support Systems: Heuristic Evaluation of a System's Usability. In: 7th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2019).
- [22] R. Klaassen, R. Van Delden, J. Vandernagel, M. Van Der Kamp, B. Thio, D. Heylen, In Body Experiences: Persuasion by Doing. In: 7th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2019).
- [23] P.M. Kluckner, A. Weiss, P. Sundström, M. Tscheligi, Two Actors: Providers and Consumers inform the Design of an Ambient Energy Saving Display with Persuasive Strategies. In: International Workshop on Behavior Change Support Systems. CEUR-WS.org (2013).
- [24] C. Konstanti, E. Karapanos, P. Markopoulos, BCD Cards: A Tool for Designing Theory-based Behavior Change Technologies. In: 7th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2019).
- [25] O. Kulyk, C.D. Das, S. David, L. Van Gemert-Pijnen, How Persuasive are Serious Games, Social Media and mHealth Technologies for Vulnerable Young Adults? Design Factors for Health Behavior and Lifestyle Change Support: Sexual Health Case. In: 3rd International Workshop on Behavior Change Support Systems. CEUR-WS.org (2015).
- [26] S.U. Langrial, F. Al, F. Al Araiimi, Social Behavior Change Messages for Tackling COVID-19 Pandemic in Oman: A Qualitative Study. In: 9th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2021).
- [27] H. Li, F.Tajariol, Persuasive System Design Principles for Pandemic: A Workshop-Based Inquiry into Comprehensibility for Designers. In: 12th International Workshop on Behavior Change Support Systems (BCSS 2024). CEUR-WS.org (2024).
- [28] A. McGowan, S. Sittig, D. Bourrie, R. Benton, S. Iyengar, A. Dalogullari, Designing For Diversity: Dynamic Persuasive Strategies in mHealth App Development. In: 12th International Workshop on Behavior Change Support Systems (BCSS 2024). CEUR-WS.org (2024).
- [29] S. Nabwire, H. Oinas-Kukkonen, Cost to Develop Persuasion in Health Behavior Change Support Systems: A Weight Management App Scenario. In: 12th International Workshop on Behavior Change Support Systems (BCSS 2024). CEUR-WS.org (2024).
- [30] C. Nutrokor, Exploring the Impact of Persuasive System Features on User Sentiments in Health and Fitness Apps. In: 9th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2021).
- [31] H. Oinas-Kukkonen, P. Karppinen, P. Tikka, A Persuasive Systems Education Program within an Information Systems Curriculum. In: 11th International Workshop on Behavior Change Support Systems. (2023).
- [32] H. Oinas-Kukkonen, M. Harjumaa, Persuasive systems design: Key issues, process model, and system features. *Communications of the Association for Information Systems*. 24, 1, 485–500 (2009). <https://doi.org/10.17705/1cais.02428>.
- [33] O. Oyebode, Deconstructing Persuasive Strategies in Mental Health Apps Based on User Reviews using Natural Language Processing. In: 8th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2020).
- [34] S. Ozono, K. Kai, M. Ori, Y. Yamazaki, C. Lian, Y. Kishimoto et al., Can a Nudge Induce Garbage Disposal Behavior? Inducement in Prosocial Behavior. In: 11th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2023).
- [35] I. Paajala, E.Y.F.E. Agyei, P. Karppinen, Conceptualizing Blockchain Utilization in Persuasive Systems Design. In: 10th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2022).
- [36] I. Paraschivoiu, T. Layer-Wagner, A. Meschtscherjakov, N. Möstegl, P. Stabauer, A Multi-stakeholder Process of Designing a City Platform for Sustainable Behavior: Lessons Learned. In: 8th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2020).

- [37] B. Peres, P.F. Campos, Understanding The Effects Of Watching a Nature Video On Informal Caregivers ' Emotional Well-Being Compared to Non-Caregivers' Emotional Well-being. In: 12th International Workshop on Behavior Change Support Systems (BCSS 2024). CEUR-WS.org (2024).
- [38] R.S.C. de Oliveira, S. Iyengar, G.T.M. Dal Sasso, Mobile health App for patients in the postoperative period of cardiac surgery. In: 11th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2023).
- [39] M. Scholten, S. Kelders, L.V. Gemert-Pijnen L, How Persuasive is a Virtual Coach in Terms of Promoting Web-based Intervention User Engagement. In: 4th International Workshop on Behavior Change Support Systems. p. 66 CEUR-WS.org (2016).
- [40] N. Sharma, L.M.A. Braakman-Jansen, J.H. Croockewit, H. Oinas-Kukkonen, L.Van Gemert-Pijnen, Communicating Care: Identifying Information and design requirements of Informal Caregivers of Older Adults with Cognitive Impairment in changing scenarios. In: 11th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2023).
- [41] A.M. Teeriniemi, T. Salonurmi, T. Jokelainen, H. Vähänikkilä, T. Alahäivälä, P. Karppinen, et al., A randomized clinical trial of the effectiveness of a Web-based health behaviour change support system and group lifestyle counselling on body weight loss in overweight and obese subjects: 2-year outcomes. *J Intern Med.* 284, 5, 534–545 (2018). <https://doi.org/10.1111/joim.12802>.
- [42] P. Tikka, B. Woldemicael, H. Oinas-Kukkonen, Building an App for Behavior Change: Case RightOnTime Building an App for Behavior Change: Case RightOnTime. In: 4th International Workshop on Behavior Change Support Systems. (2016).
- [43] P. Tikka, H. Oinas-Kukkonen, Persuading Peers in the Web: Social Influence and Tweeters vs. non-Tweeters. In: 5th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2017).
- [44] E. Triantaphyllou, Multi-Criteria Decision Making Methods. In: *Multi-criteria Decision Making Methods: A Comparative Study.* pp. 5–21 Springer US, Boston, MA (2000). https://doi.org/10.1007/978-1-4757-3157-6_2.
- [45] P. Unal, T.T.Taşkaya, P.E. Eren, An Exploratory Study on the Outcomes of Influence Strategies in Mobile Application Recommendations. In: 2nd International Workshop on Behavior Change Support Systems. p. 27 CEUR-WS.org (2014).
- [46] E. Vlahu-Gjorgievska, C. Hart, S. Basahal, K. Pokharel, K.T Win, mHealth Applications for Childhood Cancer Support and Self-management: Persuasive Systems Design features. (2021).
- [47] E. Vlahu-Gjorgievska, Y.Y Saad Alhatem, N.S.Galasau, U.Z Halim, N.M.O. Almeahadi, K.T. Win, Surfers' perceptions of safe-surfing mobile application. In: 12th International Workshop on Behavior Change Support Systems. CEUR-WS.org (2024).
- [48] B.O. Wartena, D.A. Kuipers, H.W. Van Dijk, Ludo Modi Varietas: A Game-architecture inspired design approach for BCSS. In: 2nd International Workshop on Behavior Change Support Systems. CEUR-WS.org (2014).
- [49] D. Watson, L.A. Clark, A. Tellegen, Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. (1988).
- [50] R. Whitemore, K. Knafel, The integrative review: Updated methodology, (2005). <https://doi.org/10.1111/j.1365-2648.2005.03621.x>.
- [51] I.Wiafe, D.A. Frempong, Enhancing Persuasive Features of Behaviour Change Support Systems: The Role of U-FADE. In: 3rd International Workshop on Behavior Change Support Systems. CEUR-WS.org (2015).