Interrelation of Well-being with Sustainability mindset

Among Information Technology Students

Lappeenranta-Lahti University of Technology LUT

Master of Science (Tech.) in Software Engineers for Green Deal, Master's thesis

2023

Shrawan Bishowkarma

Examiners: Professor Jari Porras (LUT University))

Professor Henry Muccini (University of L'Aquila))

Professor Patricia Lago (Vrije Universiteit Amsterdam)

With the support of the
Erasmus+ Programme
of the European Union

This thesis has been accepted by partner institutions of the consortium (619839-EPP-1-2020-1-FI-EPPKA1-JMD-MOB).

Successful defence of this thesis is obligatory for graduation with the following national diplomas:

- Master of Computer Science (University of L'Aquila)
- Master of Science in Technology (LUT University)
- Master of Computer Science (Vrije Universiteit Amsterdam)

ABSTRACT

Lappeenranta-Lahti University of Technology LUT

LUT School of Engineering Science

Software Engineering

Shrawan Bishowkarma

Interrelation of Well-being with Sustainability mindset among Information Technology students

Master's thesis

2023

118 pages, 12 figures, 44 tables and 6 appendices

Supervisors: Associate Professor Birgit Penzenstadler (Chalmers University of Technology), Dr. Leticia Duboc (La Salle – Ramon Llull University)
Examiners: Professor Jari Porras (LUT University), Professor Henry Muccini, University of L'Aquila), Professor Patricia Lago (Vrije Universiteit Amsterdam)

Keywords: well-being, sustainability, sustainability mindset, information technology

Purpose: The purpose of this study is to explore the relationship between well-being of IT students and their mindset towards sustainability. **Methodology**: Data related to well-being, well-being activities, familiarity with sustainability, belief, attitude, and intention towards sustainability was collected using survey form. For consideration of sustainability of IT products or services, SusAF data for Chat-GPT was collected. Four factors were identified for the SusAF results: Broadness, Depth, Timescale, and Synthesis. Kendall's correlation and Wilcoxon rank sum test was carried out among various aspects of well-being (well-being scores and activities for well-being) and sustainability (belief, attitude, intention, metrics for SusAF Factors). Also, qualitative analysis was done among various well-being aspects and SusAF factors. **Findings**: Overall, participants were found to have better belief, attitude and intention towards sustainability, irrespective of their well-being scores and well-being activities done by them. Statistical difference was observed for some metrics of SusAF factors, and qualitative differences in few of the factors was also observed with respect to the various aspects of well-being and well-being activities. **Conclusion**: The findings of this study has mostly resulted in an inconclusive relationship among the well-being and sustainability mindset of IT students.

ACKNOWLEDGMENTS

First and foremost, I would like to acknowledge and express my sincere gratitude to my two amazing supervisors: Dr Birgit Penzenstadler and Dr. Leticia Duboc for their guidance, support, and constructive feedback for the completion of this thesis. I am also grateful to Dr. Shola Oyedeji from LUT university for his help in gathering data for this study.

Secondly, I would like to thank all the participants of this study for taking time out of their busy schedule and making their contributions. Your participation has been a key factor to making this thesis research possible.

I would like to thank Prof. Jari Porras and the SE4GD committee for providing me with this opportunity to be part of the SE4GD program. It has been a life changing experience for me to explore, learn and grow.

Finally, I am deeply grateful to my family (my parents: Prem Bahadur Bishwakarma and Som Maya Bishwakarma) who have always believed in me and encouraged me to do better. I would also like to thank all my friends who have directly and indirectly helped me with my thesis.

ABBREVIATIONS

BPF Buddhist Peace Fellowship

CRM Customer Relationship Management

ERB Ecologically Responsible Behavior

ESB Ecologically Sustainable Behaviour

EU European Union

ICT Information and Communication Technologies

IT Information Technology

MDGs Millenium Development Goals

MM Mindfulness Meditation

PEB Pro-environmental Behaviors

PWB Diener et al's scale of Psychological Well-Being

SDGs Sustainable Development Goals

SusAD Sustainability Analysis Diagram

SusAF Sustainability Awareness Framework

SWB subjective Well-being

SWLS Satisfaction with Life Scale

UN United Nations

WHO World Health Organization

WHO-5 The 5-item World Health Organization Well-Being Index

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

As evident in the recent past, Information and Communication Technologies (ICT) has significantly influenced innovation, efficiency and effectiveness in nearly all domains [1] and lead the path towards a sustainable society and accomplishing the Sustainable Development Goals (SDGs). Considering the field of ICT as one of the fastest growing professions and preferred degree subjects for students [2], and the role of ICT in sustainable future, it is crucial for the students from this field to have sustainability mindset to address sustainability of products and services related to Information Technology (IT).

Another important aspect of every student is mental health and well-being, which directly impacts their academic performance and overall quality of life. Regular well-being activities like meditation, breathing exercises etc. are found to have positive influences on their overall mental and physical health, daily stress-handling ability, improved self-awareness, resulting in improved overall performance of students [3], [4]. Also, a study suggests that these activities may have positive correlation with the ability of participants to think sustainably and consider long term consequences of their decisions and actions more effectively [4].

Identified Research Gap: Despite well-being and sustainability being two broad concepts, there is scarcity of researches that explores the topics 'well-being' and 'sustainability mindset' together and the relationship between them. Among the existing studies, most of them associate 'mindfulness and meditation' with well-being, and primarily focus on environmental dimension of sustainability. These studies present some level of positive association between 'mindfulness and meditation' with environmental aspect (pro-environmental behaviour, ecologically responsible behaviour, and sustainable climate adaptation etc.) [5]–[10]. When the scope of research is narrowed to the field of IT, there is notably no any research available which explores both the 'well-being' and 'sustainability mindset', neither among professionals working in the industry nor the students from this field.

This scarcity of existing researches and the potential positive association between well-being and sustainability aspect as indicated by some studies highlights a need to explore the relation between these two concepts. As such, this thesis research study is carried out as one of the earliest studies to address 'well-being' and 'sustainability mindset' together in the field of IT. The primary objective of this thesis research study is to **investigate if there is any relationship between well-being and sustainability mindset among IT students**.

Following to the objective of the research, the structure of the thesis report is as follows:

- Section 1, Introduction: This chapter provides an introduction on the topic, along with identified research gap, and the primary objective of the thesis research.
- Section 2, Background and Related Works: This chapter provides the background on the topics and summary of related literature serving as the roadmap for the thesis study.
- Section 3, Research Design and Methodology: This chapter includes the literature review protocol, research hypothesis, data collection and analysis methods.
- Section 4, Results: This chapter presents the results obtained from the quantitative and qualitative analysis of the data collected.
- Section 5, Discussion: This chapter presents the discussion on the findings from the results, limitations and threats to validity of the research
- Section 6, Conclusion: This chapter concludes the with a summary of the this thesis research

The appendices section of the report includes: Appendix A (Well-being Instruments), Appendix B (Statements for Belief, Attitude, Intention towards Sustainability), Appendix C (Survey Form), Appendix D (Participant's understanding of the term 'Sustainability', Appendix E (SusAF Materials), Appendix F (Themes per dimension)

2 Background and Related Works

The three major topics related to this thesis study are: *1) Well-being, 2) Sustainability Mindset, and 3) Information and Technology*. This section presents background, context, and theories on these topics and related works about 'well-being' and 'sustainability mindset'.

2.1 Sustainability, Sustainable Development, and Sustainability Mindset

The concepts of sustainability and sustainable development have been widely gaining importance all across the world, especially over the last two decades. Sustainability, commonly is defined as "the capacity to endure", and is related with the potential for long term maintenance with respect to humans. The most widely used definition of sustainable development is the one defined by the Brundtland Report from the United Nations (UN) as the ability to "meet the needs of the present without compromising the ability of future generations to satisfy their own needs" [11]. To be considered as a sustainable development, the UN necessitates the fulfillment of three primary dimensions of sustainability – the environment, society, and economy. The environmental aspect refers to the capacity of the environment to replenish itself at a faster rate than it is destroyed by human activities. Social development focuses on building a sustainable society that is characterized by social justice, poverty reduction, and all necessary actions that promote social equity and ethical consumerism. Lastly, the economic dimension ensures a healthy balance of economic growth with our ecosystem, integrating the environmental and social concerns into business activities [12]. The concept of sustainability acts as the driving force or agenda that guides a development process to attain a sustainable level of development, for which it also sets the tone, approach or provides necessary guiding principles towards sustainable development [13].

The United Nations General Assembly in September 2015 marked a historic moment, where 193 member states of the UN officially adopted the 2030 Agenda for Sustainable Development. This agenda was developed as an urgent call for action, with 17 interlinked SDGs, calling for participation from all the countries - developed and developing, forming a global partnership. The SDGs were built on the top of the Millenium Development Goals (MDGs), which were a set of eight targets that aimed to reduce poverty and improve living standards in developing countries, adopted from the 2000s until 2015. The SDGs go beyond the MDGs, providing a comprehensive blueprint that addresses social, economic, and environmental aspects of sustainability, with focus to end poverty, protect the planet and ensure that people as well as the planet enjoy peace and prosperity, both presently and in the future. Along with a global commitment to working towards a more sustainable and equitable world, the

adoption of the 2030 Agenda alerts us about the urgent need to deal with global challenges such as poverty, inequality, climate change and many more. It also acknowledges the critical role played by all the countries, all the stakeholders including public and private sectors, to assure a sustainable future for all in a unified approach [14].

Sustainability mindset is defined as "a way to thinking and being, that results from a broad understanding of the ecosystem's manifestation, from social sensitivity, as well as an introspective focus on our personal values, and higher self, and finds its expression in actions for the greater good of the whole" citerimanoczy2020sustainability. This definition integrates the aspects of values(being) and knowledge(thinking), manifested through actions (doing). Sustainability mindset is also conceptualized as integration of systemic approach towards understanding, which goes beyond technical knowledge to understand the interconnectedness of a healthy ecosystem and a prospering society. Also, sustainability mindset of individuals is guided and shaped by their personal values and purposes.

2.2 Information Technology, Software and Sustainability

Information Technology has become an integral part of various global initiatives to achieve different Sustainable Development Goals, with the ultimate objective of securing a sustainable future. In general, the role of technology in sustainability or achieving sustainable development can be visualized from two different points of view: "Sustainability by IT" and "Sustainability in IT" [15].

"Sustainability by IT" relates to the role of Information and Technology as an enabler and enhancer towards achieving a sustainable future by helping various sectors to support sustainability, like by tackling environmental issues, simplifying business processes, resource conservation and many more [15]. The enabling role of IT makes it a crucial success factor for achieving the UN-SDGs by the year 2030, as it greatly influences the innovation, efficiency and effectiveness across various sectors of the world [1]. On the other hand, "Sustainability in IT" is concerned with the consideration of sustainable practices over the life cycle of IT goods and services from their design, development, operation and maintenance in various dimensions of sustainability.

The role of software and technology with sustainability seems to be dual, as they can contribute to the problem as well as a solution for sustainability challenges. So, it is crucial to be aware that, without sustainability mindset in both the cases, technology might have negative impacts on various aspects of sustainability [15].

2.3 Well-being, Well-being practices and Benefits

The World Health Organization (WHO) defines health as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity" [16], emphasizing the importance of well-being rather than simply being free from illness or injury. The topic "well-being : the state of being well, happy, healthy or prosperous [17]" and its associated dimensions has gained rapid interests and concerns over time [18]. While there is no single definition of well-being, it has often been used interchangeably with various concepts like happiness, health, welfare, comfort, security and safety. Well-being can be observed as a multidimensional construct which includes various aspects of one's life such as physical, emotional, mental, social, and behavioral components. Also, higher levels of well-being have been correlated with better income, work performance, physical and mental health and social relationships [19]. Some other emerging dimensions for well-being include environmental, political and spiritual dimensions [17].

In order to ensure healthy lives and promote well-being for all people at all ages, the UN has enlisted "**Good health and well-being**" as the third Sustainable Development Goal [14]. Following to this, there are various activities and practices that an individual can do to enhance each aspect of well-being and promote their overall well-being. Physical, mental and emotional resilience is necessary for experiencing a good quality of life, and various practices can be done to take care of mental and emotional well-being of individuals and help them to relax and release stress from their body. As such, there are various practices for well-being, which can be broadly categorized into (i) movement practices, like Yoga Asana, Tai Chi, QI Gong etc (ii) mental practices, like Meditation, Contemplation, and (iii) breathing practices, like Pranayama, Rebirthing Breathwork, Wim Hof, Holotropic Breathwork etc. [20]. Each of these practices are beneficial in their own way for the practitioners. For example, a study on Exercise and well-being [21] shows confirmation with growing literature on the benefits of regular exercises and physical activity, resulting with better general and health-related quality of life, better functional capacity and better mood states. Various studies on the effects of mindfulness practices among students have shown that these practices result with significant reduction of stress level, anxiety [22]–[24], enhancing stress buffering capabilities and improving the psychological well-being of the practitioners. Similarly, breathing exercises are found to have positive relation with respect to participants' mindfulness attention, awareness, and self-efficacy [20]

2.4 Well-being and Information Technology

The rapid deployment and adoption of Information Technologies in today's society has significantly influenced individual and social well-being. Various researches are exploring "Digi-

tal well-being" and how digital technologies can be leveraged to foster well-being, enhance human potential and reduce social inequality by facilitating better access to essential social services such as healthcare. In 2005, the World Health Organization acknowledged "cost-effective and secure use of Information and Communication Technologies in support of health and health-related fields" to prioritize and implement strategies of the member countries towards eHealth solutions [25], [26]. Also, today various software applications and tools, such as meditation and mindfulness apps, mood tracker, and workouts apps, designed to help users incorporate well-being practices in their daily routines and improve their overall well-being are gaining popularity. While different positive aspects of software and technology can be seen for health and well-being, there are also concerns about technologies being linked with mental health issues, well-being challenges, as well as behavioural addiction among different users [26].

"What about well-being in the field of Computer Science and Software Engineering?" A systematic literature research in software engineering found out that most of the current researches have been focused on reducing the energy footprint of software systems, highlighting a lack of attention on sustainability from software engineers perspective, and the factors responsible to meet their personal, professional needs and maintain their mental and physical well-being [27]. In the modern workplace, the significance of the effects of Information and Communication Technology on the well-being of employees, both positively and negatively, is undeniable [28]. Usually the people in technical sectors have high stress, long hours of labor, and demanding work pressure [29] which can lead to burnout and increased absence from work [28]. Researches have shown that the fast-paced work lives of software developers and other computer workers can have long-term consequences on their health and happiness. Sleep deprivation is a common issue among software developers [20], [28], and the global COVID-19 pandemic has further negatively impacted their well-being and productivity [20].

A study among software developers presented that happiness and unhappiness both impacted their productivity and performance while developing software. Unhappiness can lead to mental disorders like stress, anxiety, burnout, and depression, resulting with adverse effects on jobs, whereas happiness and well-being have been linked with higher self-accomplishment, engagement, creativity, and confidence [29]. According to a study on mental health analysis in tech workplace, the majority of tech industry workers reported experiencing mental health issues as compared to those who do not work in tech [30]. It can clearly be seen that there are challenges and concerns related to well-being and mental health in the working field of IT, computer science and software engineering that needs to be addressed appropriately. Also, the lack of individual dimension of sustainability in software engineering literature highlights the need of further researches in this area.

2.5 Well-being and Sustainability Mindset

The concept of both sustainability and well-being are related to the question of how people can live good lives without endangering the vitality of the ecosystems, making both of these topics fundamentally ethical issues. Considering a sustainable world as one where 'the Earth thrives and people can pursue flourishing lives (well-being)', Sustainability and well-being, both can also be perceived as twin concepts [31], [32]Both sustainability and well-being have a strong potential synergy between them, and their integration (sustainability in well-being or positioning well-being with sustainability) strongly influence each other [31].

As included in the definition [33], one of the core components of the Sustainability mindset is 'social sensitivity', which is cultivated in an individual-level through personal exploration of various facts and information and is shaped by a person's value, sense of purpose, preferences, assumptions, and belief. Twelve core principles of sustainability mindset were classified among four content areas, where two of the areas are 1) Spiritual intelligence (related to purpose, transcendence, and oneness) and 2) Emotional Intelligence (focused on introspective practices to promote self-awareness and explore personal value). It is clearly visible that spiritual and emotional intelligence are closely related to well-being of individuals, which are influenced by various activities they engage in for their well-being. One such activities is mindfulness practices, that will enhance individual's ability to concentrate, nurture openness, and respond flexibly to various circumstances, thereby fostering positive behavioral changes [34].

A five key sustainability competencies framework developed by Wiek et. al [35] classifies the competencies into following five groups: Systems thinking, Strategic, Interpersonal, Normative, and Anticipatory; forming a basis for sustainability mindset that encourage people to engage in meaningful and effective sustainable behaviour. Berejnoi et. al [36] suggest that one's spiritual well-being, and resulting care for others and the environment, influence these competencies of individuals, and is a critical for developing motivation to participate in sustainable behaviour and actions. Burns [37] focuses on the importance of connection with, and integration of physical, intellectual, emotional, and spiritual aspects of oneself (that can be achieved through mindfulness practices and techniques) towards promotion of ecological awareness and care. Spirituality empowers individuals to have awareness of internal and external world, foster their acceptance, empathy, and conservation of the environment, playing a vital role as the driving force of sustainability and crucial element for a healthy society in all aspects [38].

Similarly, Goralnik and Marcus [39] suggest that inner change may be particularly important for sustainability scholars and activists, who regularly deal with external sustainability challenges. Ulluwishewa [40] sums up the importance of inner-changes and spiritual well-

being for sustainability with the statement “External changes are necessary but inadequate to achieving sustainability and delivering happiness to all. Therefore, our attention should be focused on inner changes, the changes which make our relationships with fellow human beings and with nature less self-centered and more loving”.

2.6 Sustainability Awareness Framework (SusAF)

The Sustainability Awareness Framework (SusAF) was developed using Design Science [41], as a question-based framework to raise awareness of the impacts that a software system could have upon sustainability. The framework is specifically focused for software and requirement engineers to engage a broad spectrum of relevant stakeholders into interactive-collaborative discussions to discover, document and validate the system’s potential effects on sustainability, try to mitigate the potential negative effects and exploit the positive ones by making necessary adjustments to address them in the requirements of the system.

Based on the Karlskrona Manifesto [42], SusAF focuses on identifying potential positive and negative effects of IT products and services across five interrelated dimensions of sustainability: Environmental, Social, Economic, Individual, and Technical in three different systemic levels: immediate effects, enabling effects, and structural effects.

2.6.1 Five Interrelated Dimensions in SusAF

The Environmental Dimension - covers the use and stewardship of natural resources, and the questions in the this dimension are related to the topics of (1) Material and resources; (2) Soil, Atmospheric and water pollution; (3) Energy; (4) Biodiversity and land use; (5) Logistics and transportation

The Social Dimension - covers the relationships between individuals and groups, and the topic addressed in this dimension include (1) Sense of community; (2) Trust; (3) Inclusiveness and diversity; (4) Equity; (5) Participation and communication

The Economic Dimension - covers the financial aspects and business values, and the topics addressed in this dimension include (1) Value; (2) Customer Relationship Management (CRM); (3) Supply chain; (4) Governance and processes; (5) Innovation and R&D

The Individual Dimension - covers individual freedom and agency (the ability to act in an environment), human dignity and fulfillment, and includes the ability of individuals to thrive, exercise their rights, and develop freely **??**. The topics addressed in this dimension are (1) Health; (2) Lifelong learning; (3) Privacy; (4) Safety; (5) Agency

The Technical Dimension - refers to the longevity of the technical systems and infrastructures, as their ability to maintain and evolve over time with changing surrounding conditions and respective requirements [41], [42]. The topics addressed in this dimension include (1) Maintainability; (2) Usability; (3) Extensibility and adaptability; (4) Security; (5) Scalability.

2.6.2 The order of effects in SusAF

Immediate Effects are first order, direct effects that arise from the production, operation, use and disposal of socio-technical systems.

Enabling effects include effects that arise from the operation and use of a system, and any change enabled or induced by the system over time.

Structural effects represent structural changes observable at the macro level, caused by the ongoing operation and wide-scale use of the socio-technical system over time.

2.6.3 Sustainability Awareness Diagram (SusAF)

Apart from the five-question sets addressing different topics for each sustainability dimension, Sustainability Analysis Diagram (SusAD) is used to visualize the various chains of effects identified across different dimensions and different levels of effects. The template of the SusAD is shown in Figure 2 below.

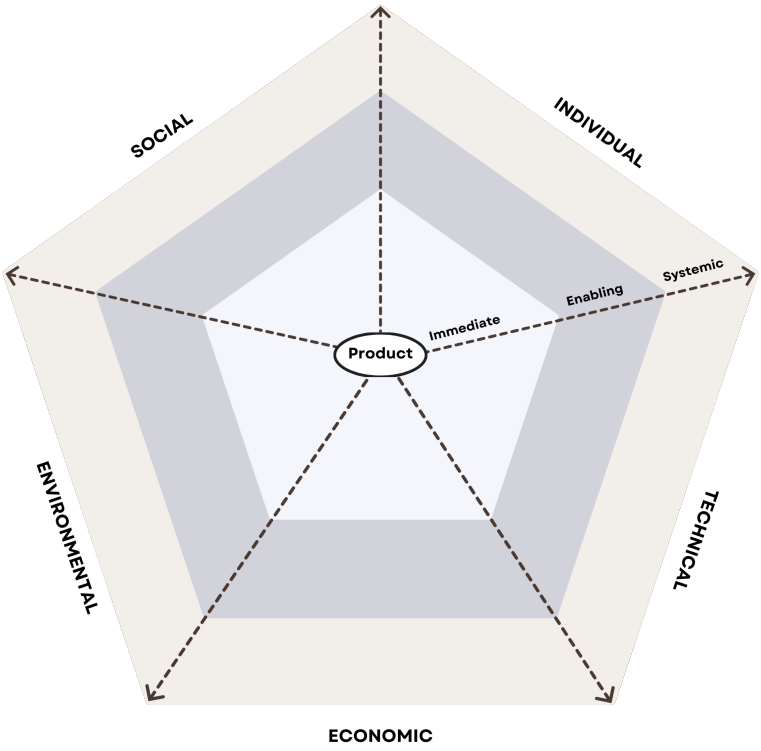


Figure 2: Sustainability Analysis Diagram Template

2.7 Related Works: Well-being and Sustainability Mindset

A reflexive thematic analysis [5] of semi-structured interviews with 13 active meditators identifies eudaimonic well-being as one of the five themes for mindfulness-induced behavior changes. As such, the participants confirmed that practicing mindfulness increased their commitment to Pro-environmental Behaviors (PEB), and that the changes were gradual and slow, and mostly reflected as a small part of a broader process towards improvement in well-being and social environment. The practitioners agreed on mindfulness helping them to recognize nature as an important source of joy and well-being for them, and hence the encouragement in the PEB. While no claims of causality could be made, a positive relationship was indicated by the study between engagement with mindfulness practices and PEB. This study clearly addresses the lack of qualitative research on the topic of "mindfulness" and "sustainability nexus", highlighting the need for more research on this. As the study is focused on meditators, it is not suitable to generalize the results of this study. The study fails to address the general well-being of participants, and limits the sustainability mindset aspect to the PEB.

A review on 30 years of research identified 'enhanced health and subjective well-being' as one of the six leading theoretical links between mindfulness and sustainability. The review highlights that several research studies present correlation between mindfulness, personal health, subjective well-being and sustainability. While various studies have verified the positive impact of mindfulness on personal well-being, there is rising awareness that individual with higher level of well-being are more inclined to adopt a more sustainable lifestyle [43], indicating possibility of positive correlation among well-being and sustainable lifestyle of individuals.

A literature review study [6] on the topics of subjective well-being and sustainability suggests promoting mindfulness could contribute both more sustainable ways of life and to a greater well-being. It mentions the likelihood of the impact well-being has on our perception and approach towards sustainable behavior. Various studies suggest that happiness is correlated with various forms of sustainable behavior. Individuals with higher subjective well-being (SWB) reported more Ecologically Responsible Behavior (ERB) among adolescents and adults [44], the relationship being linked by intrinsic values and mindfulness of the participants. Although this study acknowledges the subjective well-being, it is important to note that the sustainability aspect is limited to the environmental dimension.

A study among 605 individuals found out that those with sustainable values, and attitudes had higher levels of well-being [45], and this relationship was found stronger when well-being was further categorized into four elements: personal feeling, personal functioning, interpersonal feeling, and interpersonal functioning. However, this study was particularly focused

on the well-being of individuals being influenced by their sustainable values, attitudes, and behavior.

A literature study [46] highlights the potential of mindfulness to support a broader, and cultural shift towards sustainability, and facilitate adaptation with increasing risk and climate change at all scales, from individual to the institutional and societal level. This is supported by a survey study among 217 citizens from Lomma, Sweden, which found out that individuals' intrinsic mindfulness is positively associated with their motivation to take (or support) climate adaptation actions at different scales, especially those that are pro-social and/or pro-environmental in nature [7], indicating that mindfulness may be able to facilitate sustainable climate adaptation. Similarly, a 10-week mindfulness and compassion-based intervention (European Union (EU) Climate Leadership Program) among high-level decision makers [8] show significant increase in environmental self-identity pro-environmental behavior, reduction in climate anxiety, and the effects being extended from individual level to the collective and organizational spheres. It can clearly be seen that these studies mainly emphasise on the 'mindfulness" and 'environmental aspect of sustainability', highlighting the necessity of studies on various dimensions of well-being and sustainability mindset.

Analysis of data collected over four-years by the French National Statistical Institute confirmed positive correlation between various dimensions of subjective well-being and pro-environmental behaviour (PEB) [9]. This study addresses that both subjective well-being and PEB are multidimensional notions; however the study is still limited to the environmental aspect of sustainability, and fails to incorporate other dimensions of sustainability.

A study among 433 participants found out that adults having higher levels of nature relatedness had stronger sustainability attitudes, and higher levels of psychological well-being. Although the study does not directly study the relation between sustainability attitudes and psychological well-being, it suggests that those individuals who interact with nature might be inspired to develop healthy habits for their well-being, and the possibility to cultivate their sustainability attitudes with respect to the environment, society, and economy for such individuals is higher [47].

Berejnoi et al. [36] conducted a pilot study to examine if 15-week university course that promotes sustainable behaviour through contemplating practices increased spiritual development, well-being and happiness traits, which are theorized to increase sustainable behaviour. The quantitative analysis on results indicate increment in student self-compassion and happiness due to those practices, while no effect was observed in the sustainable behaviour. However, the qualitative reports shows that, along with development of spiritual traits, system's thinking mentality and an awareness in their interconnectedness, the students assigned greater importance to spiritual well-being as a prerequisite for sustainable behaviour.

A survey study among 829 respondents from the Buddhist Peace Fellowship (BPF) found significant correlation (moderate to moderately strong) between Ecologically Sustainable Behaviour (ESB) scales with the subjective Well-being (SWB): Semantic Differential and General Happiness, highlighting that happy people have better ecologically responsible ways of living. Jacob et al. [10] analysed data from these 829 survey and identified spiritual practice of Mindfulness Meditation (MM) as the link between these two aspects (ESB and SWB), finding significant associations between MM, ESB, and SWB, and signifying that mindfulness meditation is good for both personal and planetary well-being. It can be observed that these studies also fail to address the overall dimensions of sustainability.

It is empirical to point out that mindfulness and ecological behavior are correlated, indicating that mindfulness may foster behavioral changes towards sustainability. A cross-sectional study among 310 participants, shows that the 'acting with awareness' aspect of mindfulness has direct and weak positive relation to sustainable food consumption [48]. As per the sustainability-adapted mindfulness-based intervention [49] among two different samples (60 university students, and 71 employees), neither self-reported behavior nor attitude changed overall, however reduced materialistic value orientations and increased well-being was witnessed, suggesting indirect benefits of mindfulness for promoting individuals towards more sustainable lifestyles.

A literature review on mindfulness and social sustainability presents that mindfulness has benefits on an individual level (promoting cognitive, emotional, behavioral, physiological, and other well-being benefits), and social sustainability at organizational level, which could then have positive effects on collective social sustainability when guided by the systems thinking perspective. While this literature is limited to the mindfulness aspect of well-being, it clearly mentions that studies about mindfulness and sustainability mainly focus on the environmental aspect, highlighting the research-gap in social sustainability concepts and other concepts of sustainability [50].

Zollo, Maurizio, et al. [4] carried out a randomized controlled trial with 82 graduate business students, and found that sahaja yoga, a specific type of yoga-meditative practice, was more effective than cognitive training practices for development of sustainable decision-making mindset, improvement of neuro-psychological traits as shown by increased gray matter density in inferior frontal gyrus, as well as improvements in character traits, and ethical beliefs. In fact, the neuro-cognitive training practices showed marginally negative effects on ethical traits and sustainable decision-making mindset of the participants. Doing meditative practices can help individuals to expand their self-awareness, enabling them to enhance their ability to think, feel, and act more collectively along with consideration for long-term consequences of their decisions and actions more effectively.

Motivation for this thesis research: Based on the related works on the field of "well-being" and "sustainability mindset", it is observable that not enough research is available in the relationship exploration between well-being and sustainability mindset. Most of the studies focus on 'mindfulness and meditation' when it comes to well-being, and on 'environmental aspect' of sustainability. Although these studies address only some aspects of well-being and some aspects of sustainability, they present some level of relationship between these aspects indicating that working on well-being might help individuals to consider sustainability in their daily lives, which also implies to those working in the domain of IT. However, no existing research was found that explores the relationship between 'well-being' and 'sustainability mindset' in the field of IT. This absence of studies and the potential positive impact of well-being on sustainability consideration in the domain of IT emphasize the need for research in this area to understand the potential relationship between these two concepts.

The Table 1 shown below presents brief summary on the findings from the related works and identified research gap.

Table 1: Related Works - Summary

Reference	Summary	Identified Gap
[5]	Practicing meditation increases pro-environmental behaviours (PEB) and help recognize nature as an important source of well-being	Focused only on meditation and environmental dimension of sustainability; Has only active meditators as participants
[43]	Several research present correlation between mindfulness, perosnal health, subjective well-being and sustainability; A raising awareness that individuals with higher level of well-being are more inclined to adopt a more sustainable lifestyle	A need of further research to explore the correlation among well-being and sustainable lifestyle
[6]	Promoting mindfulness could contribute to more sustainable ways of life (behaviour)	Focused only on mindfulness
[44]	Individuals with higher subjective well-being (SWB) reported more ecologically responsible behavior (ERB) among adolescents and adults	Focused only on environmental dimension of sustainability
[45]	Individuals with sustainable values, and attitudes had higher levels of well-being	Focused on well-being being influenced by sustainable values, attitudes, and behavior rather than the way around
[46]	Mindfulness has potential to support a broader and cultural shift towards sustainability (climate change risks adaptation)	Addresses only mindfulness and environmental aspect of sustainability
[7]	Mindfulness may be able to facilitate sustainable climate adaptation	Addresses only mindfulness and environmental aspect of sustainability
[8]	10-week mindfulness and compassion-based intervention show significant environmental self-identity pro-environmental behavior, reduction in climate anxiety	Addresses only mindfulness and environmental aspect of sustainability
[9]	Positive correlation between different dimensions of subjective well-being and pro-environmental behaviour	Addresses only environmental aspect of sustainability
[47]	Higher levels of nature relatedness had stronger sustainability attitudes, and higher levels of psychological well-being	Does not directly explore the relationship of well-being and sustainability attitudes
[36]	Students realized the importance of spiritual well-being as a prerequisite sustainable behavior (Qualititative analysis)	Only focused on spiritual well-being
[10]	There is significant associations between mindfulness meditation (MM), ecologically sustainable behaviour (ESB), and subjective well-being (SWB), signifying that mindfulness meditation is good for both personal and planetary well-being	Does not directly explore the relationship between SWB and ESB; nly focused on Environmental aspect of sustainability
[48]	'Acting with awareness' aspect of mindfulness has direct and weak positive relation to sustainable food consumption	Only focused on mindfulness and sustainable food consumption
[49]	Reduced materialistic value orientations and increased well-being after sustainability-adapted mindfulness-based intervention suggests indirect benefits of mindfulness for promoting individuals towards more sustainable lifestyles	Focused only on the benefits of mindfulness
[50]	Mindfulness has benefits on individual level (promoting cognitive, emotional, behavioral, physiological, and other benefits) and social sustainability at organizational level	Focused only on mindfulness, and individual and social sustainability
[4]	Doing meditative practices can help individuals to expand their self-awareness, enabling them to enhance their ability to think, feel, and act more collectively along with consideration for long-term consequences of their decisions and actions more effectively.	Focused only on meditative practices, and does not address well-being

3 Research Design and Methodology

This section explains the design and methodology used in order to carry out the thesis research. It contains the literature review protocol used to conduct the literature studies for the research along with definition of research questions, search terms and combination used, research hypotheses, standard instruments used, questionnaire design and data collection methods, followed by data analysis methods. The overall steps involved is summarized in the Figure 3 as shown below.

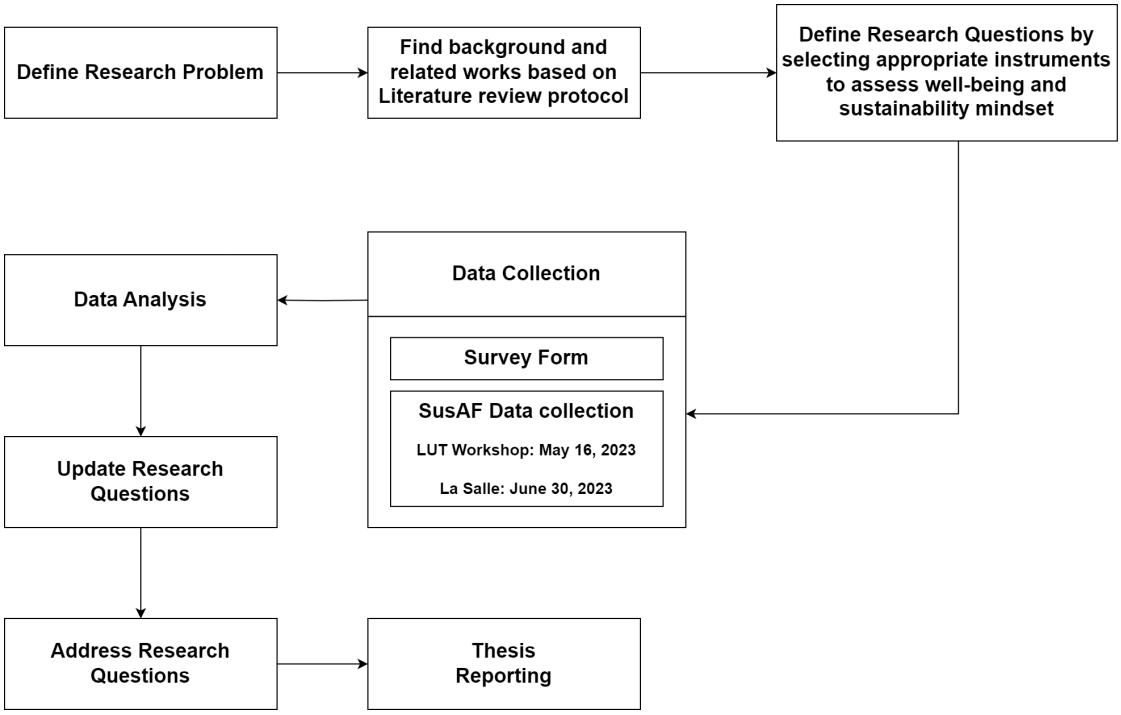


Figure 3: Research process steps

3.1 Literature Review Protocol

This section outlines the methodology used to conduct the literature review for the thesis, which involves defining research questions, identifying relevant sources and databases, appropriate search terms and combinations, as well as applying inclusion and exclusion criteria.

3.1.1 Research Questions

The thesis is focused on exploring the relationship of well-being with sustainability mindset among IT students. As such, in order to meet the objectives of the thesis, one main research question has been formulated.

Main RQ: What is the relationship of well-being of IT students with their sustainability mindset?

The main research question aims to understand whether there is any relationship between the well-being of IT students and their mindset towards sustainability. Well-being includes the well-being score calculated through standard instruments, and their mindset is explored by their belief, attitude, and intention towards sustainability (data collected through survey), and their ability to consider sustainability effects of IT products and services (SusAF data). Understanding this relationship can provide valuable insights to make strategies for promoting well-being of students and enhancing various aspects of sustainability mindset.

To answer the main research question, the following sub-research questions have been made:

Sub RQ1: What is the relationship of well-being of IT students with their belief, attitude, and intention towards sustainability?

Exploring this research question gives us insights on relationship between various instruments used to measure well-being of the students and various statements to assess their belief, attitude, and intention towards sustainability, and see if the values are significantly among participants belonging to separate well-being groups.

Sub RQ2: What are the differences in the belief, attitude, and intention of students towards sustainability among group of participants based on their well-being practices?

This research question checks if students belonging to various groups based on their well-being activities (as presented in Table 18) have any significant difference in the belief, attitude, and intention towards sustainability.

Sub RQ3: What is the relationship of well-being of the students with their consideration for sustainability effects of IT products and services?

This research question intends to explore the relationship of well-being of students with their ability to consider sustainability effects of IT products and services. In order to analyse the sustainability effects consideration, four factors are considered, namely *Broadness, Depth, Timescale, and Synthesis*. Both quantitative and qualitative analysis (as explained in 3.5.2.2 and 3.5.4) is done to address this research questions.

Sub RQ4: What are the differences in the consideration of sustainability effects among group of participants based on their well-being practices?

This research question checks if students-belonging to various groups based on their well-being activities (as presented in Table 18) have any significant difference in the consideration of sustainability effects obtained from SusAF. Qualitative and qualitative analysis of the fac-

tors: *Broadness, Depth, Timescale, and Synthesis* (similar to Sub RQ-3) for the groups is carried out to explore this research question.

3.1.2 Search Terms and Combinations

The thesis study focuses on three major topics: **1. Well-being, 2. Sustainability Mindset, and 3. Information Technology (students)**. While the initial search query included keywords from each topic, no any relevant study was found. As such, for the related studies, only the keywords related to 'well-being' and 'sustainability mindset' were used and a general search string was formed:

General Search string

("Well-being" OR "Mental Health" OR "Emotional Health" OR "meditation" OR "mindfulness" OR "breathing") AND *("Long term thinking" OR "Sustainability mindset" OR "Sustainability Thinking" OR "Sustainability belief" OR "Sustainability Attitude" OR "Sustainability Intention" OR "Sustainability Awareness" OR "Sustainability Impact" OR "Sustainability Effects")*

3.1.2.1 Sources and Databases

In order to identify resources for the literature, various databases were explored, including *IEEE Xplore Digital Library, SpringerLink, Scopus, ProQuest, and Web Of Science* . These databases were accessed through LUT Primo[1]. The searches were carried out for abstract, title and keywords, except for Springer Link where general search was done.

3.1.2.2 Inclusion and Exclusion criteria

In order to select the most relevant resources, a set of inclusion and exclusion criteria was applied, as presented in Table 2 below:

Table 2: Inclusion and Exclusion Criteria

Inclusion Criteria	**Exclusion Criteria**
Year of publication from 2005 until present	Only abstract or poster paper available
Papers in English	Information and Papers not in English
Studies that include relationship between well being and sustainability mindset	

[1] `https://elut.lut.fi/en/it-instructions-and-study-tools/lut-primo`

Along with the papers filtered and selected from above technique, snowballing was done in order to find additional relevant sources for the background and related works. The summary of the results obtained is shown in Figure 4.

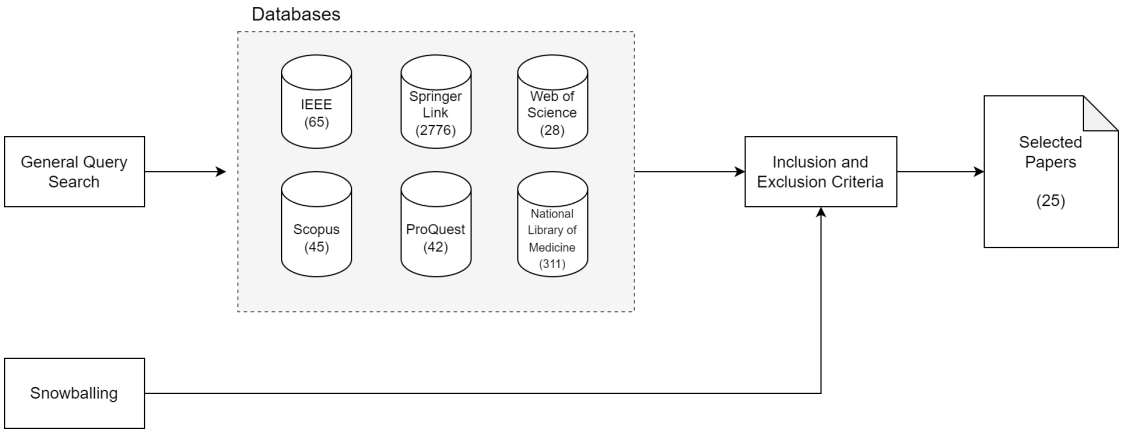


Figure 4: Search results summary

3.2 Research Hypotheses

This section includes hypotheses of the thesis work corresponding to the research questions defined above. The main hypothesis for the thesis is:

There exists a positive relationship between well-being of IT students and their mindset towards sustainability.

Similar, following hypotheses are formed with respect to the sub-research questions:

1. IT students with higher well-being have better belief, attitude, and intention towards sustainability [Sub RQ1]

2. IT students who do well-being activities (meditation and gymming group) have better belief, attitude, and intention towards sustainability [Sub RQ2]

3. IT students with higher well-being have better consideration for sustainability effects of software products and services [Sub RQ3]

   (a) IT students with higher well-being have better broadness, depth, timescale consideration, and synthesis of SusAF results.

4. IT students who do well-being activities have better consideration for sustainability effects of software products and services [Sub RQ4]

(a) IT students who do well-being activities have better broadness, depth, timescale consideration, and synthesis of SusAF results, both quantitatively and qualitatively.

3.3 Instruments

This section describes standard instruments used to collect data during survey. This includes the well-being instruments (WHO-5, PWB, and SWLS) and questionnaire about belief, attitude and intention towards sustainability. They are explained below:

3.3.1 Well-being instruments

Three standard instruments are used to measure the well-being of the participants. They are explained as follows:

1. The 5-item World Health Organization Well-Being Index (WHO-5) [51], [52]

   First published in 1998, the WHO-5 is one of the most popular instruments used to assess subjective psychological well-being of individuals [52]. It has translations of over 30 languages, and has been used widely in research. This instrument consists of simple five items (as shown in Table 39) about how the respondents have felt over the last two weeks on which they rate from the scale of 0 (None of the time) - 5 (All of the time). The WHO-5 items along with description of each rating and result interpretation of the scores is shown in Appendix A.1.

2. Diener et al's scale of Psychological Well-Being (PWB) [20], [53]

   Published in 2009 by Diener et al. [53], the scale of Psychological Well-being (PWB) broadly assesses various aspects of psychological well-being. This instrument consists of eight items about important aspect of human functioning such as positive relationships, self-esteem, having purpose and meaning in life, and optimism, where the respondents rate each items from the scale of 1 (Strongly Disagree) - 7 (Strongly Agree), as shown in Appendix A.2.

3. Satisfaction with Life Scale (SWLS) [54] [55]

   Designed in 1985, the SWLS instrument used to assess global life satisfaction. This instrument consists of five items where the respondents rate each item from the scale of 1 (Strongly Disagree) - 7 (Strongly Agree). The SWLS items are shown in Appendix A.3.

3.3.2 Instrument for belief, attitude and intention towards sustainability

In order to assess the belief, attitude and intention of the participants towards sustainability, the questions used in the existing study ”Correlation between sustainability education and engineering students' attitudes towards sustainability” [56] were used. There are 6 items related to belief, 13 items related to attitude, and 6 items related to intention, where respondents rate each item from the scale of 1 - 5, and *1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly agree*. These items are shown in Appendix B.

3.4 Questionnaire Design and Data Collection

In order to address the research questions described above, data collected using two different ways are used: 1. Survey Data and 2. SusAF Data

3.4.1 Survey Data

First, a survey form was designed that compiled various sections related to demographics, well-being, and sustainability and was circulated among the students. The demographics included a nickname (a unique identifier for data analysis), age, gender, attending university, faculty of study, and current education level of the participants.

To address the well-being of participants, three standard instruments designed to assess well-being were used namely WHO-5, PWB and SWLS (3.3.1). All of these use likert-style response scales, which are useful for quantifying the total score for each scale. Also, participants were asked about their well-being activities and how often they performed those activities in order to assess their well-being activities.

To address the sustainability aspect, the survey consisted of questions related to their familiarity with sustainability, which included their understanding of the term ”sustainability” and their source of information on sustainability. Also, data about the participants beliefs, attitudes, and intentions toward sustainability (3.3.2) were collected. The questionnaires used in the survey are included in Appendix C.

The participants were informed about the purpose of the research study, various types of data collected, potential benefits for participation, identification of the researchers, along with potential risks and discomforts. Also, consent was obtained from the participants, indicating that their participation was completely voluntary and that they had the right to withdraw from the study at any time. All of these details were explained in the description of the survey form used to collect the data.

3.4.2 SusAF Data

Along with assessing belief, attitude and intention of participants towards sustainability, another aspect used to explore their sustainability mindset is their consideration of sustainability effects of software products and services. For this, SusAF analysis was done by the participants individually on Chat-GPT [2]. A subset of questions was selected from each dimension of SusAF after discussion with the supervisors, such that it is enough for the research purpose.

A SusAF workshop of 110 minutes was carried out among the participants from the LUT university to collect the data, where as the answers submitted by students as part of their assignments were collected from LaSalle - Ramon Llull University. The students from LaSalle university were suggested to consider same time of workshop to complete the SusAF. The questionnaires used for the SusAF was same for the participants from both of the universities.

The product definition used for the SusAF workshop, its description, along with the questionnaires of the SusAF is included in the Appendix E.

3.5 Data Analysis

In order to gain proper insights, both quantitative and qualitative analysis of the data is carried out in this research. The process used to analyze the collected data are as follows:

3.5.1 Data Cleaning and Pre-processing

Data cleaning and pre-processing was done for various components of data collected through survey, and SusAF results. They are explained as follows:

3.5.1.1 Updated keywords for well-being activities

There were various well-being activities collected from the respondents through survey as 'Activities for physical well-being', 'Activities for mental well-being' and 'other activities'. Some activities, although had same meaning had separate way of representation, as such those activities were given same keywords. Some of the examples are shown in Table 3

3.5.1.2 Data Transferring from SusAF to suitable format for analysis

The data collected through SusAF workshop was transferred to suitable format for analysis. During this, data cleaning was also carried out. Following things were done as part of data cleaning.

[2] https://openai.com/blog/chatgpt

Table 3: Well-being activities data cleaning and pre-processing

Original Responses	**Updated keyword**
gym; Gym 6 days a week	gymming
Walk; Walking; Walking averaging about 55 kms per month	walking
I read books on a wide range of topic	walking
Write my journal; Journaling	journaling

- Some of the effects were not classified into positive or negative effects. Such effects were classified into positive or negative effects by the author based on the nature of effect identified when reading it.
- In the list of effects, some effects were not classified into the order of effects, however put in the SusAD diagram. So, order was assigned to by the author with reference to the SusAD diagram.
- Some effects that were not descriptive enough are not considered for the analysis.
- Some of the SusAD diagrams did not have any chain of effects or the direction of chain was not defined, as such for the quantitative depth analysis (3.5.2.2), these responses were not considered.

3.5.1.3 Translation of Spanish answers to English

The responses of participants from La Salle - Ramon Llull University were in Spanish (2 in survey form, and 4 in SusAF). As such, these responses were translated to English, for the translation Chat-GPT was used. Some examples of translation are shown in Table 4:

Table 4: Spanish to English translation of data

Source	**Spanish Response**	**English Translated Response**
Survey Form	Ejercicio en casa	Exercise at home
Survey Form	Tomar conciencia y crear las acciones correspondientes para que nuestras actividades diarias no afecten el medio ambiente.	Raise awareness and take the necessary actions to ensure that our daily activities do not impact the environment.
SusAF	Toma de decisiones errada por información sesgada	Wrong decision making due to biased information
SusAF	Aparición de nuevo producto en los catálogos de las empresas de servicios TIC: implantación chatGPT	Appearance of a new product in the catalogs of ICT service companies: ChatGPT implementation

3.5.2 Quantitative Analysis

This section includes the quantitative analysis used for the data collected through survey and SusAF.

3.5.2.1 Descriptive Statistics, Correlation and Statistical Difference

In order to understand the characteristics of the sample population, various demographic variables such as age, gender, university, faculty, and education level are analysed. There are three instruments used to measure well-being score namely WHO-5, SWLS, and PWB. **Descriptive statistics** summary of participants for each instrument was calculated, and Cronbach's alpha[3] was used to test the internal consistency among various items of each instrument.

In order to examine the **correlation** between well-being scores and various factors for sustainability mindset including beliefs, attitude, intention and quantitative metrics gathered from the SusAF data, Kendall's correlation coefficient[4] ($\boldsymbol{\tau}$) was computed. To compare the **statistical difference** among various groups based on well-being and well-being activities, Wilcoxon rank sum test[5] was carried out.

Non-parametric tests (Kendall's correlation coefficient and Wilcoxon rank sum test) were chosen instead of parametric tests (Pearson's correlation [6] and t-tests [7] for group comparison) because these parametric tests assume normal distributions of data; however, this criteria of normal distribution is not fulfilled in data collected for this research.

In order to do the statistical test, R[8] programming language was used. Also, excel[9] was used to do some data transformation, analysis and creating visual representations such as graphs.

3.5.2.2 Quantitative Metrics for SusAF:

Each factor have metrics obtained from the SusAF analysis. The metrics for Broadness, Depth, and Timescale have been derived with reference to the codebook containing information extracted from SusAD [41]. The quantitative metrics for each factor are as follows:

[3] https://stats.oarc.ucla.edu/spss/faq/what-does-cronbachs-alpha-mean/

[4] http://www.sthda.com/english/wiki/correlation-test-between-two-variables-in-r#kendall-correlation-formula

[5] http://www.sthda.com/english/wiki/unpaired-two-samples-wilcoxon-test-in-r

[6] https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/correlation-pearson-kendall-spearman/

[7] https://www.statisticssolutions.com/t-test/

[8] https://www.r-project.org/

[9] https://www.microsoft.com/en-us/microsoft-365/excel

1. Broadness of sustainability analysis - The broadness of sustainability analysis assesses the level of wide-coverage of sustainability effects in the SusAF. The quantitative metrics used to analyse the broadness are shown in Table 5:

Table 5: Broadness quantitative metrics

Metric	**Description**
number of potential effects	This metric presents the total number of potential effects identified by the participants. Higher number of effects indicates more coverage of effects, contributing to the higher broadness of the sustainability analysis.
number of positive and negative effects	This metric gives us the insights on the broadness of the consequence of impacts (either beneficial or adverse), contributing to overall broadness of sustainability analysis. Higher number of positive and negative impacts signify higher broadness per type of consequence,, contributing to higher broadness of sustainability analysis.
average number of effects per dimension	This metric indicates the broadness within various dimensions of sustainability. Higher number of effects per dimension indicate higher broadness per dimension, contributing to higher broadness of sustainability analysis.

2. Depth of sustainability analysis - The depth of sustainability analysis assesses the interconnection among the sustainability effects as mapped in the SusAD, and the quantitative metrics used to analyse the depth are shown in Table 6:

Table 6: Depth quantitative metrics

Metric	**Description**
number of chains of effects	The number of chains of effects represents the number of interconnected effects which contribute to sustainability impact. Higher number of chains signify higher detailed analysis of causal relationship between various effects identified.
average length of chains of effect	This metric gives the average length of chains of effects linked in SusAD. Higher length implies that participants were able to identify higher detailed causal link among effects indicating better depth of analysis.

3. Timescale of sustainability analysis - The timescale of sustainability analysis assesses the nature of the impacts over different time frames. As such, following three quantitative metrics are used to analyse time scale as shown in Table 7:

   In order to check the correctness of these order of effects, the order of effects for each effect were categorized by the researcher and his classmate, and then compared with the original data of the participants.

Table 7: Timescale quantitative metrics

Metric	Description
number of correctly identified immediate effects	Immediate effects contribute to the short-term or immediate consequence of impact identified. Higher number of immediate effects indicate higher identification of short-term effects.
number of correctly identified enabling effects	Enabling effects signify a longer term effects as compared to the immediate effects, and higher number of enabling effects indicate identification of more numbers of longer term effect.
number of correctly identified structural effects	The structural effects signify the macro level effects that have possibilities to cause structural changes. Higher number of enabling effects indicate identification of long-term effects signifying long-term thinking compared to other effects.

4. Synthesis of SusAF - The synthesis includes translating effects into threats and opportunities, and developing actions to mitigate threats and support the opportunities. The metrics used to analyze the synthesis is shown in Table 8:

Table 8: Synthesis quantitative metrics

Metric	Description
number of mitigating actions	These are the actions to mitigate the threats identified. Higher number of mitigating actions signify higher identification of threats, and reflects proactive nature to address potential sustainability threats, and minimize their negative impacts.
number of supporting actions	These are the actions to support the effects identified as opportunities. Higher number of supporting actions signify higher identification of opportunities, and reflects proactive nature to address potential sustainability opportunities and maximize their positive impacts.

3.5.3 Qualitative Analysis

Need for Qualitative Analysis: The quantitative metrics (3.5.2.2) used to analyse the results from SusAF can provide some insights and indicators to explore sustainability mindset of the participants. However, they do not capture the full complexity and depth of sustainability mindset. Focusing only on the quantitative numbers related to effects would give a false impression that higher number of effects indicates better sustainability mindset, which is not always true, and hence the quantitative approach would be inadequate for the analysis. As such, qualitative analysis is carried out for better understanding of the results. In order to do the qualitative analysis, the following things are done.

1. Firstly, all the effects were categorized into various themes, such that each theme include effects that are similar.

2. Themes consisting participants of different well-being groups, well-being activity group etc. were identified for the qualitative analysis.

3. For each relevant themes, effects were classified into various levels of broadness, depth, timescale, and synthesis factors, and comparative analysis among participants belonging to different groups was done.

   (a) Broadness of sustainability analysis
   The broadness of sustainability analysis is assessed by level of coverage of sustainability effects identified in the SusAF. Each effect is classified into one of the three level of broadness: **Basic** (Effects that are specific and limited), **Moderate** (Effects that cover certain domain but are not universal), and **High** (Effects that cover wide range of scenario, globally).

   (b) Depth of sustainability analysis
   The depth of sustainability analysis is assessed by level of detail and thought put in the sustainability effects. Each effect is classified into one of three level of depth: **Basic** (Simple effect statement with no explanation), **Moderate** (Effects statement with basic reasoning), and **High** (Effects that has detailed, multi-level reasoning and include more thought)

   (c) Timescale of sustainability analysis
   The timescale of sustainability analysis is assessed by exploring the richness of correctly identified structural effects. Each correctly identified structural effect is classified into one of three level of richness: **Basic** (Simple and straightforward effect statement that only gives general overview), **Moderate** (Effect with better exploration and impact in relevant scope with moderate level of impact), and **High** (Effect that seems extensively explored and cause global wide-spread discussions and cascading impacts).

   (d) Synthesis of sustainability analysis
   The synthesis of sustainability analysis an analyzed qualitatively by exploring how well the participants manage to convey the actions to mitigate threats and support the opportunities.

3.5.4 Data Analysis Summary

The overall summary of process of data analysis for this thesis is presented in Figure 5.

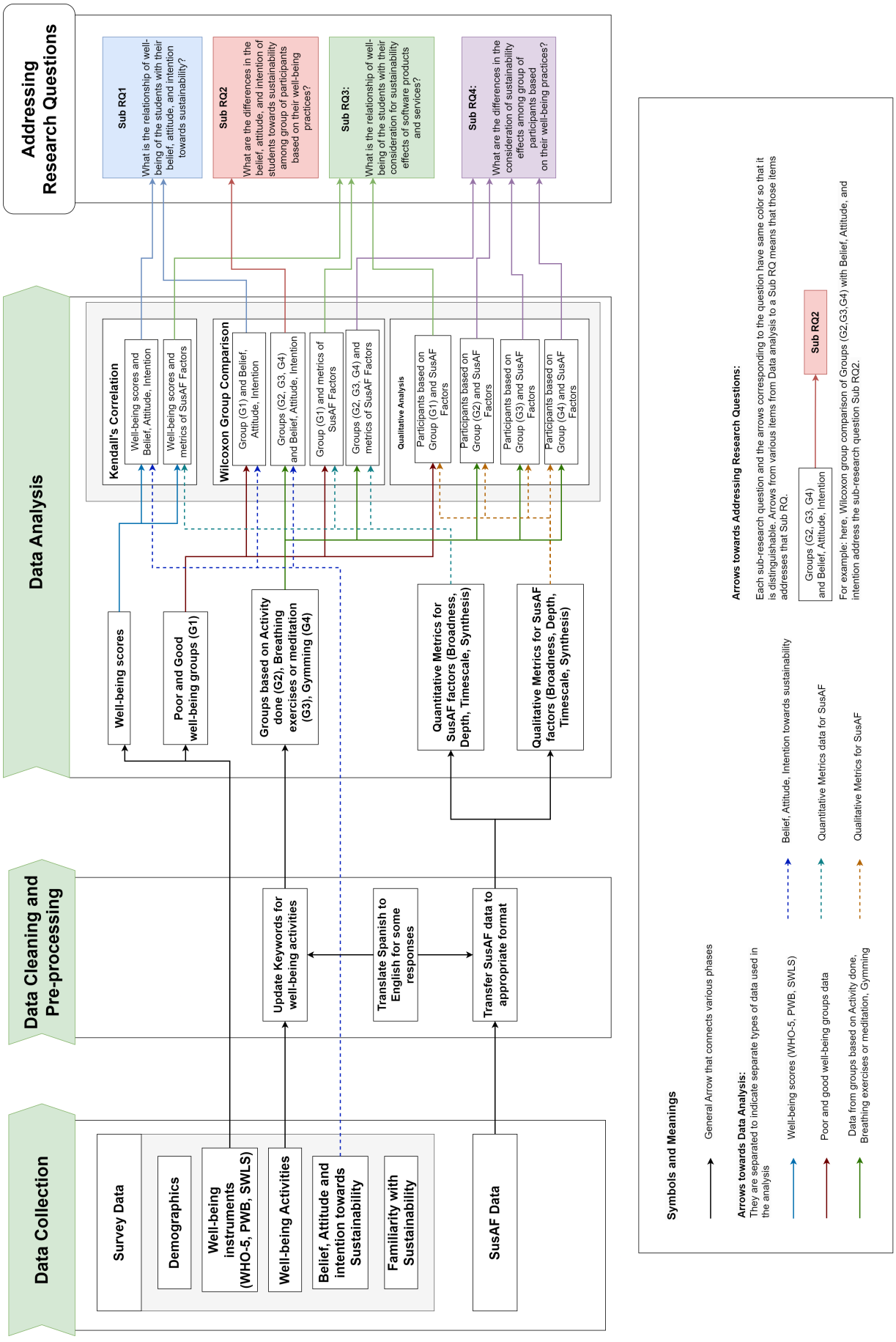


Figure 5: Data Analysis Process

4 Results

This section presents results based on the analysis of data collected through survey and SusAF, which includes both quantitative and qualitative analysis.

4.1 Demographics

A total of 32 participants filled the survey form, among which 2 participants did not submit the SusAF data, and hence their responses were excluded from the analysis. As a result, there are 30 valid participants, and their demographics are presented as follows:

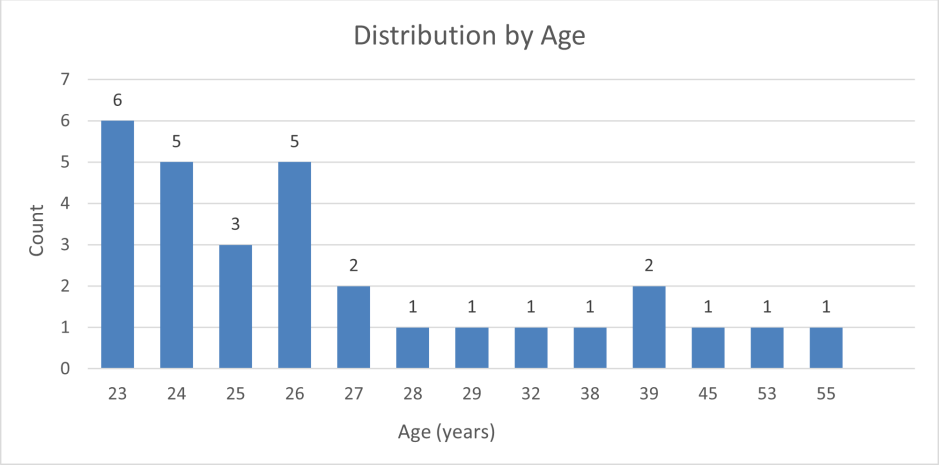
Table 9: Demographics by Age (n=30)

Demograhics	Min	Mean	Median	Max
Age (Years)	23	29.167	26	55

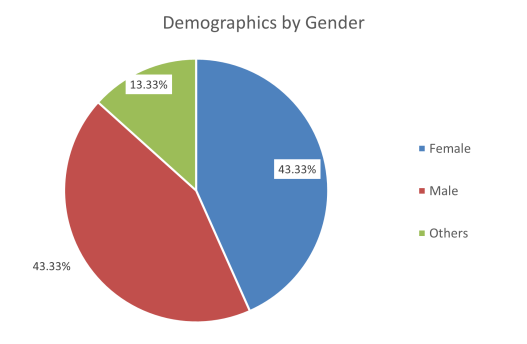
Table 10: Demographics by Gender, University, Faculty, Education Level (n=30)

Demographics	**Levels**	**Count**
Gender	Male	13
	Female	13
	Others	4
University	LUT	24
	La Salle	6
Faculty	Software Engineering	24
	IT	6
Education Level	Masters degree - Year 1	24
	Masters degree - Year 2	5
	PhD - Year 2	1

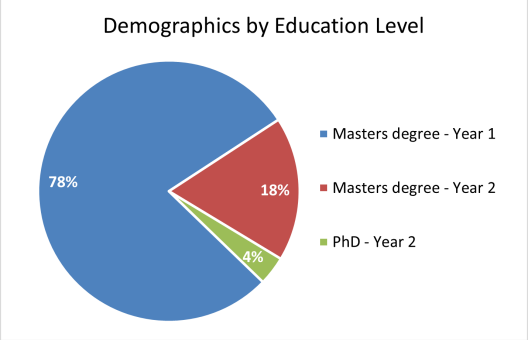
As shown in Table 9 and Figure 6a, age of participants ranged from 23 - 55 years, with average age of 29.167 years, and maximum participants were 23 years old. Equal number of participants were Male and Female (13 each) as indicated by Table 10. Majority of the participants were Masters degree - Year 1 students (24), followed by Masters degree - Year 2 (5) and Phd - Year 2 (1). Also, 80% of the participants were from LUT University (Software Engineering faculty), and remaining 20% from La Salle - Ramon Llull University (IT faculty). The demographics are graphically illustrated in Figure 6.



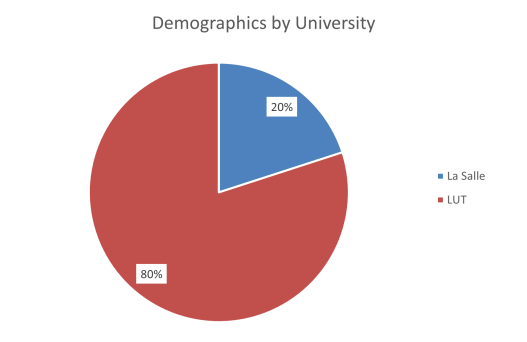
(a) Age



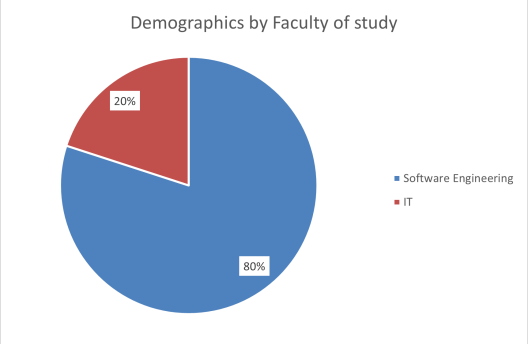
(b) Gender



(c) Education Level



(d) University



(e) Faculty

Figure 6: Distribution of Participants by demographics

4.2 Well-Being Statistics

In order to measure the well-being of participants, three standard instruments were used : WHO-5, PWB and SWLS. The descriptive summary statistics for each instruments are presented below.

4.2.1 WHO-5 Statistics

The Table 11 shown below gives descriptive statistics for each statement (Appendix A.1) belonging to measure WHO-5 well-being score. It can be seen that the average of WHO-5 well-being score among all the participants is 14.233. The total score ranges from 4 (poor well-being with possibility of depression) to 24 (very high score of well-being) indicating high range of WHO-5 well-being score among the participants.

Table 11: WHO-5 well-being statistics (n=30)

Item	Min	Q1	Median	Mean	Q3	Max	SD
who-1	1	3	3	3.167	4	5	0.95
who-2	0	2	3	2.8	3	5	1.126
who-3	1	2.25	3	3.067	4	5	1.048
who-4	0	1	2	2.233	3	4	1.135
who-5	1	2	3	2.967	4	5	1.066
who-total	**4**	**11.5**	**15**	**14.233**	**16**	**24**	**4.141**

Min: Minimum, **Max**: Maximum, **Q1**: First Quartile, **Q3**: Third Quartile, **SD**: Standard Deviation
who-total: Sum of score of all WHO-5 items

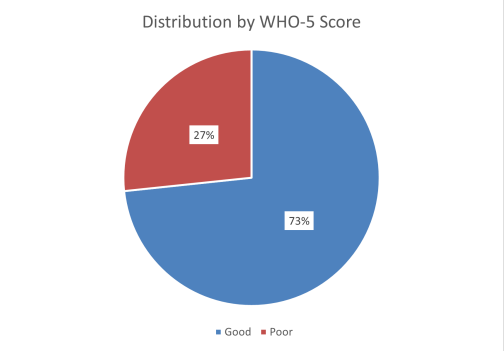
The calculated Cronbach's alpha value of 0.839 presents a relatively high level of internal consistency among various items of the WHO-5 well being instrument.

Similarly, based on the total score, the participants has been classified into two groups: Good and Poor well-being, as shown in Table 12 below:

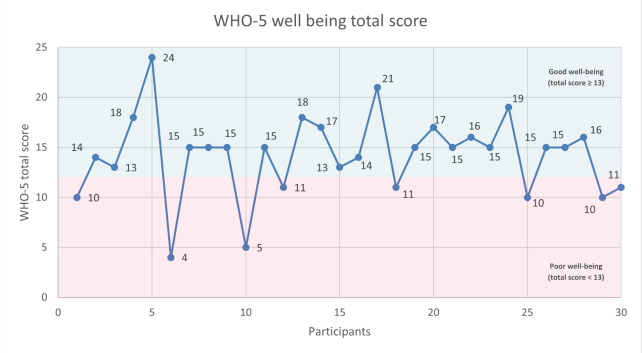
Table 12: WHO-5 well-being group

Status	Count	Min	Q1	Median	Mean	Q3	Max	SD
Good	22	13	15	15	16.136	17	24	2.606
Poor	8	4	8.75	10	9	11	11	2.828

It can be seen that 8 out of 30 participants have poor well-being (mean score 8.75) with score ranging from 4-11, and remaining 22 (mean score 16.136) have good well-being with score ranging from 13-24 [51].



(a) WHO-5 Score Group



(b) WHO-5 Items Scores

Figure 7: Distribution of Participants by WHO-5 score

4.2.2 PWB Statistics

The Table 13 shown below gives descriptive statistics for each statement belonging to measure PWB well-being score. The average of total PWB score among all the participants is 43.567, and the total score ranges from 25 to 55, with standard deviation value of 7.3.

Table 13: PWB well-being statistics (n=30)

Instrument	Min	Q1	Median	Mean	Q3	Max	SD
pwb-1	2	4	5.5	5.2	6	7	1.324
pwb-2	4	5	6	5.567	6	7	0.898
pwb-3	1	5	5	5.133	6	7	1.383
pwb-4	3	5	5.5	5.333	6	7	1.124
pwb-5	4	5	6	5.8	6	7	0.887
pwb-6	2	5	6	5.8	7	7	1.324
pwb-7	1	4.25	6	5.233	6	7	1.633
pwb-8	2	5	6	5.5	6	7	1.042
pwb-total	**25**	**40.5**	**46.5**	**43.567**	**48**	**55**	**7.3**

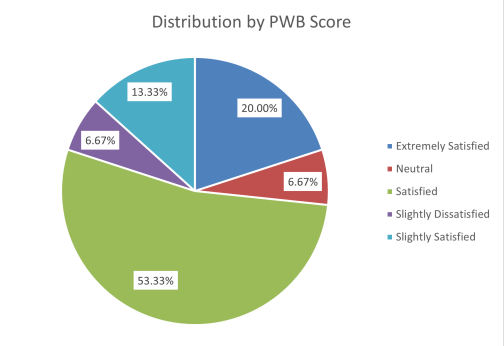
pwb-total: Sum of score of all pwb-items

The calculated Cronbach's alpha value of 0.878 presents a relatively high level of internal consistency among various items of the PWB instrument.

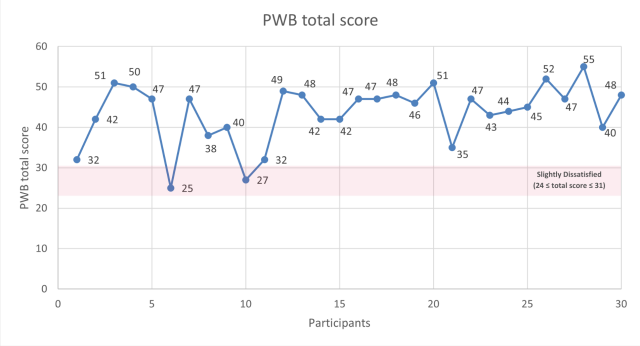
Similarly, based on the total score, the participants has been classified into five different groups as shown in Table 14. Out of 30 participants, only 2 of them were found to be slightly dissatisfied psychological well-being, and 2 of them belonged to the neutral group. While 4 of them are slightly satisfied, 16 of them are Satisfied, 6 of them are extremely satisfied based on the PWB total score.

Table 14: PWB well-being group

Status	Count	Min	Q1	Median	Mean	Q3	Max	SD
Extremely Satisfied	6	49	50.25	51	51.333	51.75	55	2.066
Satisfied	16	42	43.75	47	45.625	47	48	2.277
Slightly Satisfied	4	35	37.25	39	38.25	40	40	2.363
Neutral	2	32	32	32	32	32	32	0
Slightly Dissatisfied	2	25	25.5	26	26	26.5	27	1.414



(a) PWB Score Group



(b) PWB Items Scores

Figure 8: Distribution of Participants by PWB score

4.2.3 SWLS Statistics

The Table 15 shown below gives descriptive statistics for each statement belonging to measure SWLS score. It can be seen that the average of total SWLS score of participants is 24.1, and the total score ranges from 16-33 with standard deviation of 4.196.

Table 15: SWLS statistics (n=30)

Instrument	Min	Q1	Median	Mean	Q3	Max	SD
swls-1	1	4	5	4.667	5.75	7	1.322
swls-2	2	4	5	4.8	5	7	1.095
swls-3	1	5	6	5.267	6	7	1.311
swls-4	2	5	6	5.2	6	7	1.157
swls-5	1	3	4	4.167	6	7	1.704
swls-total	**16**	**21**	**24.5**	**24.1**	**26**	**33**	**4.196**

swls-total: Sum of score of all swls-items

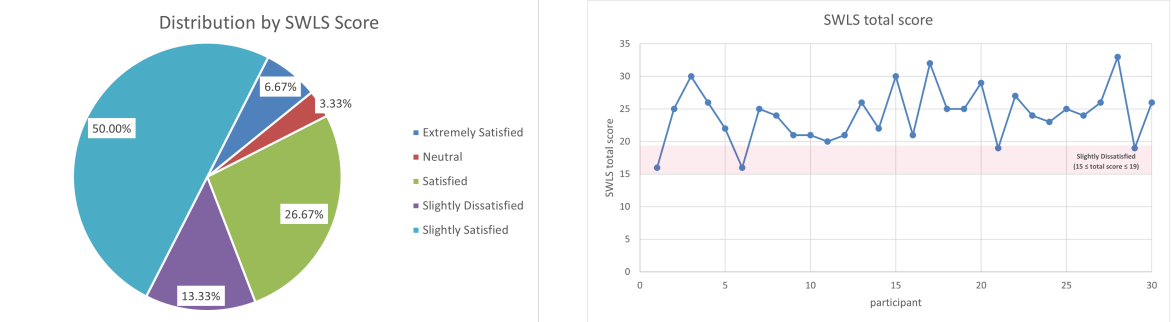
The calculated Cronbach's alpha value of 0.668 presents a moderate level of internal consistency among various items of the SWLS instrument.

Similarly, based on the total score, the participants has been classified into five different groups as shown in Table 16 below:

Table 16: SWLS group

Status	Count	Min	Q1	Median	Mean	Q3	Max	SD
Extremely Satisfied	2	32	32.25	32.5	32.5	32.75	33	0.707
Satisfied	8	26	26	26.5	27.5	29.25	30	1.852
Slightly Satisfied	15	21	21.5	24	23.2	25	25	1.699
Neutral	1	20	20	20	20	20	20	-
Slightly Dissatisfied	4	16	16	17.5	17.5	19	19	1.732

It can be observed that four out of 30 participants belong to slightly dissatisfied group based on SWLS score, and one of them belong to the neutral group. 15 of them are slightly satisfied, 8 are satisfied, and 2 participants have extremely satisfied life, based on the SWLS score.



(a) SWLS Score Group

(b) SWLS Items Scores

Figure 9: Distribution of Participants by SWLS score

Selection of well-being group: Looking at the well-being statistics, it can be observed that higher number of participants have poor well-being (8 out of 30) based on WHO-5 score, as compared to PWB (2 out of 30 belong to slightly dissatisfied group), and SWLS (4 out of 30 belong to slightly dissatisfied group). The slightly dissatisfied groups of PWB and SWLS constitute very small sample group for statistical and qualitative analysis. Also, it was observed that all the participants with slightly dissatisfied PWB status, and 3 out of 4 participants with slightly dissatisfied SWLS status had belonged to poor WHO-5 well-being status. Hence, WHO-5 based group is selected for the group-based comparison as presented in Table 17. However, for the correlation analysis, all three instruments have been used.

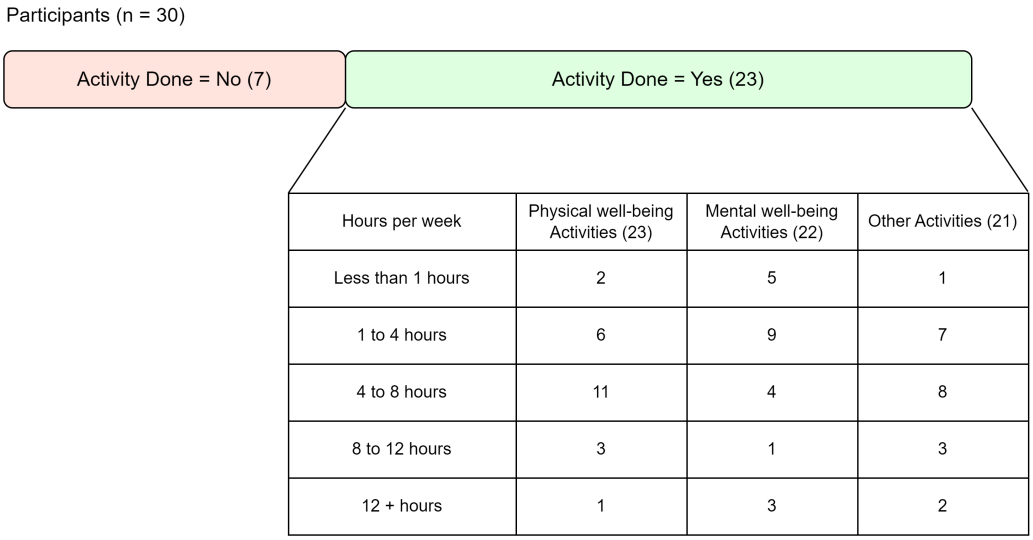
Table 17: Selection of well-being group (n=30)

Instrument	Count	Remarks
WHO-5	Poor (8) Good (22)	Relatively larger sample size between two groups compared to PWB and SWLS **(Selected for grouped statistics)**
PWB	Slightly Dissatisfied (2) Neutral, Slightly Satisfied, Satisfied, Extremely Satisfied (28)	- Very small sample size between groups - All slightly dissatisfied participants have poor WHO-5 well-being status **(Rejected for grouped statistics)**
SWLS	Slightly Dissatisfied (4) Neutral, Slightly Satisfied, Satisfied, Extremely Satisfied (26)	- Very small sample size between groups - 3 out of 4 dissatisfied participants have poor WHO-5 well-being status **(Rejected for grouped statistics)**

4.3 Well-Being Activities Statistics

This section presents the statistics on well-being activities done by the participants. Participants were asked to list out the activities they do for their physical well-being, mental well-being, and any other activities for their well-being separately in the survey.

Among 30 participants, 7 of them do not do any activities for their well-being, and remaining 23 do various activities for their well-being. All of the 23 participants do activities for their physical well-being, 22 of them do activities for their mental-well being, and 21 of them do other activities for their well-being. Figure 10 presents the summary of statistics for well-being activities along with hours per week invested by participants for various well-being activities.

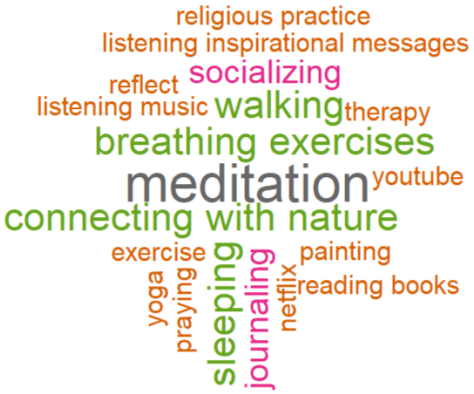


Hours per week	Physical well-being Activities (23)	Mental well-being Activities (22)	Other Activities (21)
Less than 1 hours	2	5	1
1 to 4 hours	6	9	7
4 to 8 hours	11	4	8
8 to 12 hours	3	1	3
12 + hours	1	3	2

Figure 10: Well-Being Activities Statistics

Among various activities done for physical well-being, **gymming (12)** and walking (12) are topmost activities done by participants. For mental-well being, **meditation (5)** is the topmost activity done, followed by **breathing exercises (3)**, connecting with nature (3), walking (3), and others. Similarly, cooking (10) was done most by the participants as other activities for their well-being. The word clouds shown in Figure 11 illustrates various activities done by the participants for their well-being. The size of each word in the word cloud corresponds to the frequency of that particular activity among the participants of this study.

(a) Physical well-being activities



(b) Mental well-being activities

(c) Other activities for well-being

Figure 11: Word cloud of various well-being activities

Selection of well-being activities for comparative analysis: In order to do the comparative analysis among participants based on well-being activities, three different categories have been selected. They are shown in table 18 below.

Table 18: Categories of well-being activities for comparative analysis (n=30)

Category	Count	Description
Well-being activity	Yes (23) No (7)	Two groups based on whether participants did any activities for their well-being
Breathing Exercises or Meditation	Yes (8) No (22)	Groups based on whether participants did any breathing exercises or meditation for their mental well-being
Gymming	Yes (12) No (18)	Groups based on whether participants did gymming for their physical well-being

4.4 Sustainability Familiarity Summary

This section includes results on various sources that contribute to the participant's familiarity with sustainability, activities that they do for sustainability in their daily lives. Participant's understanding for the term "sustainability" is presented in Appendix D

4.4.1 Source for familiarity with sustainability

In order to understand the extent to which various sources have contributed to the familiarity with sustainability, the participants were asked to rate from 1 - 5 on five different source-statements. The summary of the familiarity with sustainability is shown in Table 19.

Table 19: Sustainability Familiarity Source Statistics (n = 30)

Sources for familiarity	**Not at all (1)**	**To a small extent (2)**	**To some extent (3)**	**To a great extent (4)**	**To a very great extent (5)**
I read about sustainability from news, websites, and social media	0	4	**13**	11	2
I discuss about sustainability with my friends, families or colleagues	0	6	**11**	8	5
I have read books (at least one) about sustainability	3	5	8	5	**9**
I learn through active engagement in community activities or political action	5	**11**	9	4	1
I study about sustainability in academic courses	0	2	5	8	**15**

In general, it can be observed that most of the participants read about sustainability and discuss about sustainability with in their circles from small to a very great extent, with highest numbers belonging to the group of 'to some extent (rating = 3)'. Small number of participants (2) have not read any book about sustainability. 5 participants did not engage in community or political activities to learn about sustainability, and 11 of them engage in these activities to a small extend (rating = 3), indicating less participant learnt about sustainability through these activities. Similarly, half of the participants (15) highlighted that they studied about sustainability in academic courses to a very great extent (rating = 5).

Overall, it can be observed that that most of the sources highly contribute to the familiarity of participants with sustainability, except for active engagement in community activities or political action, which has less contribution compared to other sources.

4.4.2 Activities for sustainability in daily life

A total of 47 unique activities were listed as activities done by participants for sustainability in daily lives, which is presented as a word cloud in Figure 12. The size of each word in the word cloud corresponds to the frequency of that particular activity among the participants.

Among these activities, **recycling** was done by most of the participants (10), followed by avoiding electric energy wastage (7), waste segregation (5), and then others.

Figure 12: Activities for Sustainability in daily life

4.5 Sustainability Mindset Statistics

This section presents statistics on the measurements of sustainability mindset which includes belief, attitude, and intention towards sustainability, along with various quantitative metrics obtained from the SusAF analysis.

4.5.1 Belief towards Sustainability

Table 20 shows that the mean score of five items (except for statement B4) for belief related to sustainability range from 3.8 - 4.267, agreeing to feeling more obliged to do something for environmental and social problems, and take responsibility for sustainable development. For the statement of B4 about humans having right to subdue and control the nature, the mean score was 2.933, indicating lesser level of belief with this statement compared to others.

Table 20: Sustainability Belief Statistics (count = 30)

ID	Statement	Median	Mean	SD
B1	I feel more morally obliged to do something about environmental problems.	4	4.2	0.551
B2	I feel more morally obliged to do something about social problems.	4	3.967	0.615
B3	I think I should take more responsibility for sustainable development.	4	4.267	0.583
B4	I believe that humans have the right to subdue and control nature.	3	2.933	1.311
B5	I believe that humans should adapt to nature rather than modify it to suit them.	4	4.033	1.066
B6	I think it is important to control human population to ensure social sustainability.	4	3.8	1.095

4.5.2 Attitude towards Sustainability

Table 21 shows that the mean score of eleven items for attitude related to sustainability (except A6 and A13) range from 3.8 - 4.533, agreeing higher with these statements. For the statement of A13 about willing to pay more for energy-efficient products (mean = 3.467), and A6 about refusing the use of packaging (mean = 3.2), the mean score was comparatively lower than other statements indicating lesser agreement with these statements.

Table 21: Sustainability Attitude Statistics (n = 30)

Id	Statement	Median	Mean	SD
A1	I am more aware of current environmental, social, economic and cultural issues	4	4.267	0.583
A2	I can analyse issues related to sustainable development more holistically	4	3.8	0.664
A3	I am more concerned about environmental pollutions	4	4.067	0.691
A4	I am more willing to safeguard sustainable development	4	3.967	0.615
A5	I make an effort to use green products and services whenever possible	4	4.1	0.759
A6	I refuse the use of packaging	3	3.2	0.805
A7	I set aside garbage for reuse, recycling or safe disposal	5	4.533	0.681
A8	I reduce the use of air-conditioning, lighting and domestic electrical appliances	4	4.067	0.944
A9	I consciously make a change in my lifestyle to reduce my carbon footprint	4	4.067	0.868
A10	I consciously reduce the amount of wastes generated from my daily activities	4	4.067	0.785
A11	I make an effort to use energy and resources more efficiently	4	4.3	0.466
A12	I reduce water consumption	4	3.867	0.973
A13	I am willing to pay more for energy-efficient products	4	3.467	1.008

4.5.3 Intention towards Sustainability

Table 22 shows that participants have higher mean score ranging from 3.933 to 4.433 for all the statements related to the intention towards sustainability, indicating that they have better intention towards sustainability.

Table 22: Sustainability Intention Statistics (n = 30)

Id	Statement	Median	Mean	SD
I1	I prefer to work for an environmentally responsible employer in the future	4.5	4.4	0.675
I2	I prefer to work for a socially responsible employer in the future	5	4.433	0.679
I3	I intend to change/continue to change my lifestyle for better sustainability	4	4.367	0.615
I4	I will promote the concept of sustainable development to my family and friends	4	4.367	0.615
I5	I will participate in campaigns/causes that promote sustainable development	4	3.933	0.785
I6	I will apply the concept of triple bottom line (Economic, Social, Environmental impacts) more in making decisions	4	3.967	0.669

4.6 SusAF Results Descriptive Summary

This section contains the overall summary of SusAF results for various metrics as shown in Table 23. A total of 522 effects were identified by 30 participants, with 220 positive and 302 negative effects. Most of the effects were identified for Individual dimension (131) followed by Social (113), Economic (107), Environmental (90) and Technical (81). Among all the effects identified, 32 immediate effects, 119 enabling effects, and 49 structural effects were correctly identified. A total of 40 opportunities and 88 threats with corresponding actions were listed by the participants.

Table 23: SusAF Descriptive Summary (n=30)

Metric	Count	Min	Q1	Median	Mean	Q3	Max	SD
Effects	522	5	11.25	16.5	17.4	20	42	7.868
Positive	220	1	3.25	7	7.333	9.5	20	4.943
Negative	302	2	7.25	9	10.067	12	22	4.339
Social	113	1	2.25	4	3.767	4	10	1.87
Individual	131	1	3	4	4.367	6	9	2.109
Environmental	90	0	2	3	3	4	6	1.414
Economic	107	1	2	3	3.567	4	11	2.269
Technical	81	1	2	2	2.7	3	9	1.803
Immediate(correct)	32	0	1	1	1.067	1.75	3	0.785
Enabling(correct)	119	0	2	3	3.967	4	19	3.855
Structural(correct)	49	0	0	1	1.633	2	9	2.092
Opportunities	40	0	0	1	1.333	2	8	1.729
Threats	88	0	1	2	2.933	4	11	2.677

Immediate(correct), Enabling(correct) and Structural(correct) are the count of effects that have been correctly categorized into corresponding order of effects as explained in Table 7.

4.7 Results for Sub RQ1: Well-Being and Belief, Attitude, and Intention towards sustainability

This section contains correlation analysis among three instruments of well-being and belief, attitude and intention towards sustainability, as well as statistical analysis to compare the significant difference on the value of belief, attitude, and intention among various groups of participants based on the well-being score. As such, the results in this section address the sub-research question **'Sub RQ1: What is the relationship of well-being of the students with their belief, attitude, and intention towards sustainability?'**.

4.7.1 Correlation Analysis

Table 24 [1] presents the kendall's correlation (τ) with corresponding p-value between well-being scores obtained from the three instruments (WHO-5, PWB, and SWLS) and statements related to belief, attitude, and intention towards sustainability.

It can be observed that no significant correlation was found among the well-being scores (WHO-5, PWB, SWLS) and the statements related to belief, attitude and intention towards sustainability, as p-value for all the pairs are greater than 0.05. For the WHO-5 and a statement related to intention (I2: I prefer to work for a socially responsible employer in the future), there was no correlation **(p-value=1)**, signifying no association between this pair. And for all other pairs, the observed associations were either negligible positive or negligible negative.

[1] In Table 24, the negative value of τ signifies negative association whereas the positive value of τ signifies positive association between the variables. A statistically significant correlation is highlighted by the symbol *, and absence of * signifies that the correlation between the variables is not statistically significant and there is not enough evidence to conclude that there is a meaningful relationship between the variables.

Table 24: Correlation of well-being scores with belief, attitude, and intention towards sustainability

Statement	WHO-5 score		PWB score		SWLS score	
	coeff (τ)	p-value	coeff (τ)	p-value	coeff (τ)	p-value
Belief Items						
B1	-0.059	0.708	0.064	0.679	0.064	0.679
B2	0.105	0.496	0.022	0.883	0.003	0.983
B3	0.073	0.643	0.151	0.326	0.174	0.259
B4	-0.122	0.406	-0.188	0.191	-0.175	0.224
B5	0.15	0.315	0.11	0.456	0.085	0.566
B6	0.017	0.907	-0.269	0.068	-0.1	0.502
Attitude Items						
A1	0.106	0.5	0.247	0.108	0.275	0.076
A2	-0.22	0.154	-0.096	0.527	-0.08	0.598
A3	0.262	0.089	0.134	0.376	0.141	0.354
A4	0.184	0.234	0.057	0.705	0.01	0.95
A5	0.189	0.223	0.29	0.057	0.246	0.108
A6	-0.009	0.952	0.24	0.107	0.164	0.274
A7	0.239	0.131	0.246	0.114	0.119	0.448
A8	-0.018	0.907	0.054	0.713	-0.257	0.085
A9	-0.045	0.768	0.092	0.534	0.015	0.923
A10	0.081	0.592	0.044	0.768	-0.233	0.121
A11	0.011	0.945	0.154	0.328	-0.134	0.4
A12	0.062	0.675	0.077	0.597	-0.1	0.497
A13	-0.061	0.686	0.032	0.826	0.074	0.616
Intention Items						
I1	0.151	0.331	0.205	0.179	0.009	0.952
I2	**0**	**1**	0.095	0.531	-0.037	0.809
I3	0.263	0.093	0.262	0.089	0.157	0.311
I4	-0.058	0.713	0.131	0.395	-0.044	0.777
I5	0.251	0.097	0.23	0.122	0.155	0.3
I6	0.006	0.967	-0.006	0.968	-0.129	0.396

The statements related to belief, attitude, and intention are available in Appendix B

4.7.2 Group Comparison (good vs poor well-being group)

The significant difference on the value of belief, attitude, and intention was compared among poor and good well-being groups based on the WHO-5 well-being scores using the Wilcoxon rank sum test. The results are presented in Table 25.

Table 25: Comparison of belief, attitude, and intention statements score among good and poor well-being group

Statement	**p-value**	**Statement**	**p-value**
Belief Items		*Intention Items*	
B1	0.321	I1	0.45
B2	0.891	I2	0.937
B3	0.464	I3	0.599
B4	0.215	I4	0.875
B5	0.073	**I5**	**0.045***
B6	0.485	I6	0.916
Attitude Items (1-7)		*Attitude Items (8-13)*	
A1	0.464	A8	0.326
A2	0.396	A9	0.595
A3	0.261	A10	0.858
A4	0.642	A11	0.745
A5	0.379	A12	0.902
A6	0.776	A13	0.677
A7	0.827		

The statements related to belief, attitude, and intention are available in Appendix B

Based on the p-value obtained for the Wilcoxon test, it can be said that values of belief, attitude, and intention statements between good and poor WHO-5 well-being groups are not significantly different, except for WHO-5 and intention statement (I5: I will participate in campaigns/causes that promote sustainable development) whose p-value is 0.045 (<0.05). Considering this significant difference, right-tailed Wilcoxon test was carried out among good and poor well-being groups such that,

The null hypothesis is "*There is no difference in the value for Intention (I5) statement between good well-being and poor well-being groups*", and

The alternative hypothesis is "*The value for Intention (I5) statement for good well-being*

group are greater than ratings for poor well-being group".

The observed **p-value was 0.022** (<0.05), based on which **we can reject the null hypothesis**, and accept the alternative hypothesis concluding that there is strong evidence to suggest that the value of Intention (I5) statements are higher for good well-being group compared to poor well-being group.

4.8 Results for Sub RQ2: Well-Being activities group and Belief, Attitude and Intention towards Sustainability

This section of results addresses the sub-research question **'Sub RQ2: What are the differences in the belief, attitude, and intention of students towards sustainability among group of participants based on their well-being practices?'**.

To get the answers to Sub RQ2, significant difference on the value of belief, attitude and intention statements within various groups of participants based on well-being activities, breathing practices or meditation, and gymming (as presented in Table 18) was compared using Wilcoxon ranksum test. The results of the group comparison are shown in Table 26.

No significant difference was found for all the statements related to belief, attitude, and intention among the groups based on well-being activity and breathing exercises or meditation. For the groups based on gymming, significant difference was found for Attitude statement (A11: I make an effort to use energy and resources more efficiently) and Intention statement (I2: I prefer to work for a socially responsible employer in the future), indicating that the groups who do and do not do gymming have different values for these two statements.

For Gymming and Attitude (A11) statement (I make an effort to use energy and resources more efficiently), the observed p-value was 0.004. Considering this statistically significant difference, right-tailed Wilcoxon test was carried out among the groups who do gymming, and do not do gymming, such that **The null hypothesis is** "*There is no difference in the value of Attitude (A11) statement between gymming and non-gymming groups*", and
The alternative hypothesis is "*The value of Attitude (A11) statement for gymming group are greater than value for non-gymming group*".

The observed **p-value was 0.9982** (>0.05), based on which **we fail to reject the null hypothesis**, and conclude that there is not enough evidence to support the alternative hypothesis.

Similarly for Gymming and Intention statement (I2: I prefer to work for a socially responsible employer in the future), the observed p-value for the right-tailed Wilcoxon test was 0.9844 (p

> 0.005), indicating that we do not have enough evidence to support our alternative hypothesis that gymming groups have better value for Intention (I2) compared to non-gymming groups.

Table 26: Comparison of belief, attitude, and intention statements score within groups based on well-being activities (WBA), breathing practices or meditation (BPM), gymming (GYM)

Statement	**WBA (p-value)**	**BPM (p-value)**	**GYM (p-value)**
Belief Items			
B1: I feel more morally obliged to do something about environmental problems.	0.225	0.35	0.818
B2: I feel more morally obliged to do something about social problems.	0.607	0.888	0.361
B3: I think I should take more responsibility for sustainable development	0.183	0.262	0.941
B4: I believe that humans have the right to subdue and control nature.	0.347	0.577	1
B5: I believe that humans should adapt to nature rather than modify it to suit them.	0.405	0.876	0.381
B6: I think it is important to control human population to ensure social sustainability.	0.657	0.046	0.702
Attitude Items			
A1: I am more aware of current environmental, social, economic and cultural issues.	0.59	0.666	0.713
A2: I can analyse issues related to sustainable development more holistically.	0.136	0.192	0.288
A3: I am more concerned about environmental pollutions.	0.647	0.158	0.639
A4: I am more willing to safeguard sustainable development.	0.886	0.142	0.348
A5: I make an effort to use green products and services whenever possible.	0.438	0.245	0.206
A6: I refuse the use of packaging.	0.291	0.745	0.944
A7: I set aside garbage for reuse, recycling or safe disposal.	0.375	0.058	0.767
A8: I reduce the use of air-conditioning, lighting and domestic electrical appliances	0.713	0.032	0.107
A9: I consciously make a change in my lifestyle to reduce my carbon footprint	0.979	0.512	0.138
A10: I consciously reduce the amount of wastes generated from my daily activities	0.393	0.296	0.076
A11: I make an effort to use energy and resources more efficiently	0.323	0.191	**0.004***
A12: I reduce water consumption	0.504	0.356	0.054
A13: I am willing to pay more for energy-efficient products	1	0.893	0.221
Intention Items			
I1: I prefer to work for an environmentally responsible employer in the future	0.231	0.384	0.127
I2: I prefer to work for a socially responsible employer in the future	0.805	0.897	**0.035***
I3: I intend to change/continue to change my lifestyle for better sustainability	0.582	0.389	0.393
I4: I will promote the concept of sustainable development to my family and friends	0.869	0.748	0.128
I5: I will participate in campaigns/causes that promote sustainable development	0.033	0.098	0.566
I6: I will apply the concept of triple bottom line (Economic, Social, Environmental impacts) more in making decisions	0.913	0.968	0.394

WBA: Well-being activities based group; **BPM**: Breathing practices or meditation based group **GYM**: Gymming based group

4.9 Results for Sub RQ3: Well-being and SusAF Analysis

This section addresses the sub-research question **'Sub RQ3: What is the relationship of well-being of the students with their consideration for sustainability effects of software products and services?'**

To address Sub RQ3, quantitative analysis related to well-being and various metrics of the four factors of the SusAF analysis (Broadness, Depth, Timescale, and Synthesis) was carried out. This includes Kendall's correlation between well-being score from the three instruments with SusAF metrics, and Wilcoxon rank sum test to make comparison of the metrics among participants belonging to good and poor well being groups. And then, qualitative analysis was carried out to analyze if either of the groups have better SusAF analysis for the factors.

4.9.1 Correlation Analysis: Quantitative

Table 27 presents Kendall's correlation among well-being scores (WHO-5, PWB, and SWLS) with the metrics for Broadness, Depth, Timescale and Synthesis factors of SusAF.

Table 27: Correlation of well-being scores with the metrics of SusAF factors

Metric	**WHO-5 score**		**PWB score**		**SWLS score**	
	coeff (τ)	**p-value**	**coeff (τ)**	**p-value**	**coeff (τ)**	**p-value**
Broadness Metrics (n=30)						
No. of potential effects	0.015	0.913	0.123	0.358	0.177	0.188
No. of positive effects	-0.205	0.139	0.130	0.338	0.012	0.928
No. of negative effects	0.211	0.128	0.118	0.384	0.268	0.050
Avg. no. of effects per dimension	0.015	0.913	0.123	0.358	0.177	0.188
Depth Metrics (n=27)						
No. of chains of effects	-0.065	0.666	0.047	0.749	0.009	0.949
Avg. length of chains of effect	-0.069	0.637	0.237	0.099	0.033	0.816
Timescale Metrics (n=30)						
No. of immediate effects	0.093	0.540	0.052	0.725	0.085	0.571
No. of enabling effects	-0.016	0.912	-0.104	0.454	0.013	0.927
No. of structural effects	-0.088	0.545	0.145	0.312	0.043	0.764
Synthesis Metrics (n=30)						
No. of mitigating actions	-0.017	0.908	0.109	0.458	0.067	0.648
No. of supporting actions	0.209	0.14	0.14	0.315	0.209	0.134

No. means Number, and **Agv.** means Average

Based on the p-value as observed in Table 27, no significant correlation was found among well-being instruments score (WHO-5, PWB, and SWLS) with the metrics of the factors used to quantitatively analyse SusAF results. Also, the existing association was found to be negligibly positive or negligibly negative.

4.9.2 Group Comparison (good vs poor well-being group): Quantitative

The significant difference on the metrics used in the factors of SusAF analysis (Broadness, Depth, Timescale, and Synthesis) among the good and poor well-being groups based on the WHO-5 well-being score was compared using right-tailed Wilcoxon rank sum test, such that for each metric (M) the hypotheses are:

Null Hypothesis: *"There is no difference in value of metric (M) identified by good well-being and poor well-being groups"*, and

Alternative Hypothesis: *"The value of metric (M) for good well-being group is greater than that of poor well-being group"*

The results of this hypothesis testing among good and poor well-being groups and each metric are presented in Table 28.

Table 28: Comparison of metrics of SusAF factors among participants from good and poor well-being group

Metric	p-value	Metric	p-value
Broadness (n=30)			
No. of potential effects	0.120	No. of positive effects	0.528
No. of negative effects	0.034*	Avg. No. of effects per dimension	0.115
Depth (n=27)			
No. of chains of effects	0.559	Avg. length of chains of effect	0.833
Timescale (n=30)			
No. of immediate effects	**0.032***	No. of enabling effects	0.122
No. of structural effects	0.823		
Synthesis (n=30)			
No. of mitigating actions	0.470	No. of supporting action	0.177

As highlighted in Table 28, for one metric of broadness (**number of negative effects, p=0.034**), and one metric of timescale (**number of immediate effects, p = 0.032**), the observed p-values were less than 0.05, implying that we have enough evidence to reject the null hypothesis and

claim that the **good well-being groups have greater number of negative effects and immediate effects identified compared to the poor-well being groups**. However, for all other metrics, we do not have enough evidence to reject the null hypothesis.

4.9.3 Well-being and SusAF Analysis : Qualitative

This section includes qualitative analysis to analyze the SusAF results among participants belonging to good and poor well-being groups and compare participants belonging to which group has better SusAF analysis. This is explored by qualitatively assessing the factors: broadness, depth, timescale, and synthesis for effects identified (as explained in 3.5.4).

4.9.3.1 Theme classification for Analysis

Firstly, the effects identified by participants were grouped in various themes of each dimension. The number of themes identified in each dimension is presented in Table 29. As seen in the table, social dimension has highest number of themes (32) followed by Economic (29), Individual (28), Environmental (19) and Technical (18) dimensions.

The themes for each dimension with number of effects belonging to each theme are presented in Appendix F.

Table 29: Number of themes per dimension

Dimension (Number of effects)	Number of themes
Social (113)	32
Economic (107)	29
Individual (131)	28
Environmental (90)	19
Technical (82)	18

4.9.3.2 Theme filtration for Analysis

Each theme consists of number of participants who belong to either poor or good well-being group. The themes consisting of comparable number of participants from both poor and good well-being groups were selected for comparative analysis of effects among participants from these groups. Table 30 contains the summary of classification and grouping of effects among the groups and different dimension. It can be seen that the number of themes identified where all the participants have good well-being is considerably higher than those with poor well-being in all five dimensions.

Table 30: Classification of themes per dimension based on well-being group of participants

Theme-based groups	**Social (32)**	**Individual (28)**	**Environmental (19)**	**Economic (29)**	**Technical (18)**	**Total (126)**
All participants have good well-being	18	13	9	14	8	**62**
All participants have poor well-being	3	2	0	2	3	**10**
Mixed good-poor well-being participants	11	13	10	13	7	**54**

4.9.3.3 Well-being and Broadness Analysis

Among 54 themes with participants from good as well as poor well-being, it was observed that the broadness of sustainability effects were better for participants with both good (4 themes) and poor (2 themes) well-being, and for most of the themes (47 themes) the comparison results was not conclusive as summarized in Table 31. Based on the qualitative analysis, no appropriate evidence was found to conclude if participants from either of group has better broadness analysis, as the number of themes that had conclusive results were very less.

For examples, for the theme **Information security issues** participants having good well-being have better broadness, and for the theme **Improved task efficiency**, participants of poor well-being group have better depth, where as for the theme **Personalized Recommendation**, the depth were similar and hence the result was inconclusive, as shown below.

Theme: Improved Task Efficiency (n=4)
This theme had 4 participants with 2 participants having poor well-being and 2 participants having good well-being. Both participants with good well-being identified effects with moderate level of broadness, where as both participants with good well-being identified effects with high level of broadness in this theme. **As such, for this theme, participants with poor well-being have better broadness**. Some examples of the effects identified by the participants are as follows:

- *(Poor well-being, Moderate Broadness)*
  Reduction in the probability of making errors in tasks
- *(Good well-being, Basic Broadness)*
  Efficiency in coding can assist programmers by providing solutions

Above, it can be seen that a participant with good well-being only focuses on programmers (limited domain), where as a participant with poor-well being mentions about reduction of error making in task (wider coverage)

Theme: Reduce Waste, Energy, and resources (n=8)
This theme had 8 participants with 5 participants having good well-being and 3 participants having poor well-being.
Two participants of good well-being identified effects with high level of broadness, and remaining all participants had identified moderately broad effects. As such, **for this theme, participants with good well-being have better broadness**. Some examples of the effects identified by the participants are as follows:

- (Poor well-being, Moderate Broadness)
  ChatGPT could help reduce waste and pollution by fact checking wrong claim about climate change
- (Good well-being, High Broadness)
  Reduction of the carbon footprint

Here a participant with poor well-being specifically focuses on fact checking on claim about climate change to help reduce waste and pollution (limited to fact checking), where as a participant from good well-being focuses on reduction of carbon footprint which seems to have wider coverage.

Theme: Personalized Recommendation (n=4)
This theme had effects from 4 participants with 3 participants having good well-being and 1 participants having poor well-being.
All the participants had similar level of moderate broadness. As such, **for this theme, it was inconclusive if participants from either of well-being groups had better broadness for this theme**. Some examples of the effects identified by the participants are as follows:

- (Poor well-being, Moderate Broadness)
  Get personal recommendations for diet, exercise
- (Good well-being, High Broadness)
  Personalized recommendations

Here all the effects have similar broadness among both poor and good well-being participants, hence the comparison result is inconclusive.

4.9.3.4 Well-being and Depth Analysis

Among 54 themes consisting of participants from good and poor well-being, 12 themes had better depth analysis for participants with each good, and 12 for poor well-being, and 30 themes had inconclusive results, as summarized in Table 31. Based on the qualitative analysis enough evidence could not be found to support if participants belonging to either of the groups have better depth analysis of SusAF results.

For examples for themes **Save Time and Effort**, **Energy by Hardware and Infrastructures**, and **Impact on Employment**, participants from good well-being group have better depth analysis, and for theme **Diminished self-value**, those from poor well-being group have better depth compared to others as shown below.

Theme: Energy by Hardware and Infrastructure (n=13)
This theme had 13 participants with 10 participants having good well-being and 3 participants having poor well-being. All the effects identified by 3 participants from poor well-being group had basic depths. For good well-being, 7 of effects had basic depths and 3 had moderate depths. Overall, **for this theme, participants with good well-being have better depth analysis**. Some examples of the effects identified by the participants are as follows:

- (Good well-being, Moderate Depth)
  – Consumes lots of energy via servers and data centers for service resides. To produce the energy, fossil fuels or coals need to be burned, which results in waste and pollution
- (Poor well-being, Basic Depth)
  – High energy consumption of data centers

Here, it can clearly be seen that a participant with poor well-being only states the high energy consumption of data centers, where as the one with good well-being explain the impact is much depth.

Theme: Impact on Employment (n=23)
This theme had 23 participants with 19 participants having good well-being and 4 participants having poor well-being. All the participants with poor well-being identified effects with basic depths, where as 10 good well-being participants identified effects with basic depths, and remaining 9 identified effects with moderate depths. Overall, **for this theme, participants with good well-being have better depth analysis**. Some examples of the effects identified by the participants are as follows:

- (Good well-being, Moderate Depth)
  – ChatGPT can reduce monetary value by increasing unemployment and replacing humans
- (Poor well-being, Basic Depth)
  – ChatGPT already replaces most work within CRM in many company.

Here, a participant with poor well-being mentions about replacement of work because of ChatGPT, whereas a participant with good well-being mentions about its implication on reduction of monetary value.

Theme: Diminished self-value (n=4) This theme had 4 participants, with 1 participant having poor well-being, and 3 having good well-being. A participant with good well-being identified effect with moderate depth, where as remaining all participants had basic depths, irrespective of well-being. Some examples of effects are as follows:

- (Good well-being, Basic Depth)
  – Make a person feel under-valued
- (Poor well-being, Moderate Depth)
  – Can make person feel undervalued because there will be a threat of one's irrelevant if the AI can easily do what someone does.

  Here, the effect identified by participant with poor well-being has better depth as it provides reason for making person feel undervalued, where as the participants (1 out of 3 shown above) with good well-being fail to provide detailed reasoning.

Theme: Save Time and Effort (n=9)
This theme had 9 participants with 5 participants having good well-being and 4 participants having poor well-being. Among 4 poor well-being participants, 3 identified effects with basic depths, and 1 identified effect with moderate depth. For 5 participants with good well-being, 3 had basic depths, where as 2 had moderate depths of effects identified. Overall, **for this theme, participants with good well-being have better depth analysis**. Some examples of the effects identified by the participants are as follows:

- (Good well-being, Moderate Depth)
  – Support or assist individual in a tight schedule eg. summarize a paper so that individual spends only few minutes to read the summary instead of whole paper
  – Can save a lot of time which gives sense of productivity (can ask it to correct text for spelling, find bugs in code etc.)
- (Poor well-being, Basic Depth)
  – More free time
  – Save Time

Among the 9 effects available under this theme (above 4 listed), the participants from poor well-being group only point out the effects, where as some participants with good well-being have better reasoning and explanations for the effect.

4.9.3.5 Well-being and Timescale Analysis

In order to assess the timescale of effects, the richness of effects were checked for the total of 49 correctly identified structural effects, and comparative analysis was done. The total number of themes were 29, among which 22 of them had only one correctly identified structural effects, and 7 themes has more than one effect. Among these 7 themes, 2 themes had effects from purely good well-being group.

Among 49 effects, 14 were from participants with poor well-being, and remaining 35 effects belonged to participants with good well-being. Quantitatively, it can be observed that participants who belong to good well-being group have higher number of moderate richness for timescale analysis. However, upon analysing the richness of structural effects for the 5 comparable themes, enough evidence could not be gathered to support if participants belonging to either of the group has better timescale analysis of SusAF results.

Some of the examples of the effects with richness of the structural effects identified by participants with good and poor well being are presented below

Theme: Impact on Employment (n=11)
Among 11 structural effects correctly identified in this theme, 4 of them were from participants having poor well-being (4 basic richness) and 7 from those with good well-being (1 moderate richness, 6 basic richness). Overall, on comparison, the **timescale factor was inconclusive** for this theme. Some examples of the effects identified by the participants are as follows:

- (Poor well-being, Basic Richness)
  – Job loss in sectors such as user support
  May change job of people such as common CS
- (Good well-being, Basic Richness)
  – Job displacement in some sectors such as customer service, language teaching

The participants from poor well-being group and good well-being groups have similar richness for these structural effects. They are simply stated and lack explanations and supporting details

Theme: Inequity and Inequality in Society (n=4)
Among 4 structural effects correctly identified in this theme, 2 of them were from participants having poor well-being (1 basic and 1 moderate richness) and 2 from those with good well-being (1 basic and 1 moderate richness). Overall, on comparison, the **timescale factor was inconclusive** for this theme. Some examples of the effects identified by the participants are as follows:

- (Good well-being, Basic Richness)
  – Inequality based on social status, gender, race, religion
- (Poor well-being, Basic Richness)
  – Possibility of amplifying gender or race biases

The participants from poor well-being group and good well-being groups have similar richness for these structural effects.

4.9.3.6 Well-being group and Synthesis Analysis

In order to assess the synthesis of sustainability analysis, the actions to mitigate threats and support opportunities were qualitatively analysed.

Opportunities and Supporting Actions: A total of 40 opportunities had corresponding supporting actions, where 8 belonged to participants had poor well-being and 32 had good well-being. Among the supporting actions identified, only some of them were conveyed well by participants having poor and good well-being. **Among those actions that are conveyed well, the participants from poor well-being group were able to convey in much better way than those of good well-being group**.

Some of the examples of the supporting actions that have been conveyed well by participants having different well-being are presented below.

Properly conveyed supporting actions for opportunities by participants having good well-being

- **Opportunity: Greater efficiency and effectiveness of workers**
  Supporting Action: It is necessary to train workers in the use of ChatGPT so that they can make the most of it without compromising sensitive data
- **Opportunity: Creating new business models based on the use of ChatGPT (plugins or APIs)**
  Supporting Action: Promote collaboration with developers and companies to create plugins and APIs that allow the integration of ChatGPT into various applications and services
- **Opportunity: Decreases the effort to obtain information or perform tasks related to texts (summaries, compositions)**
  Supporting Action: Improve the algorithm to enable personalized summaries based on demand and perform more precise searches. Continuous training of the AI

Properly conveyed supporting actions for opportunities by participants having poor well-being

- **Opportunity: Improvement in production tasks that can be performed by AI**
  Supporting Action: There are many tasks that can be optimized using AI, providing greater efficiency to companies. Actions to take would be adopting this technology in different areas where behavior is entirely analytical and does not involve emotional or ethical biases, always under supervision and training of a person. Therefore, as a company, we need to make known and explain the ethical and social limitations of this tool and promote its more analytical and assisting/facilitating use.
  Training individuals to transition from operators to verifiers, prompters, or quality managers of the work
- **Opportunity: Access to information: Allows quick access to a wide range of information on various topics, facilitating learning and increasing users' knowledge.**
  Supporting Action: OpenAI should expand the coverage of topics, improve the accuracy of responses, and address misinformation and biases. It can also collaborate with experts and communities, provide documentation and educational resources, and explore options for translation and multilingualism. These actions would ensure broader and more reliable access to information through ChatGPT and provide up-to-date information as of 2023.
- **Opportunity: Quick access to information and knowledge**
  Supporting Action: The company should engage in a continuous effort to improve the algorithms that search and process information in order to select reliable sources and disregard unverified sources.

Threats and Mitigating Actions: A total of 88 threats and corresponding mitigating actions were identified by 73 participants with good well-being and 13 participants with poor well-being. It was observed that, **among the mitigating actions that are conveyed well, the participants from poor well-being group were able to convey in much better way than those of good well-being group**.

Some of the examples of the mitigating actions that have been conveyed well by participants having different well-being are presented below

Properly conveyed mitigating actions for threats by participants having good well-being

- **Threat: Replacing jobs in certain areas**
  Mitigating Action: Establish retraining and training programs to facilitate employees' transition to new job opportunities and growing sectors
- **Threat: Energy consumed by the system's servers**
  Mitigating Action: Research and apply continuous improvements in server energy efficiency and use renewable energy sources to reduce environmental impact
- **Threat: Spread of fake news or unreliable information**
  Mitigating Action: Implement mechanisms for verification and validation of information generated by ChatGPT, such as the inclusion of truth labels or identification of reliable sources

Properly conveyed mitigating actions for threats by participants having good well-being

- **Threat: Loss of critical thinking skills**
  Mitigating Action: The company can offer, especially to schools, training workshops explaining how to correctly use its application, its limitations and the need to check With reliable sources.
- **Threat: Disappearance of trades and jobs**
  Mitigating Action: The application of AI is similar to the industrial revolution, and the world must adapt to it. This will cause losses for some and benefits for others. The question is how to mitigate these threats and enhance these opportunities. AI excels in repetitive tasks, objective analytical tasks, gathering and synthesizing information, and creating new content through imitation. This should result in increased efficiency in our jobs and enable us to accomplish more with fewer resources. However, the concern is that if everyone becomes more efficient due to AI, it will directly translate into job destruction. Ideally, the value created by AI should primarily benefit individuals rather than just companies. This way, it could lead to improvements such as reduced working hours or better work-life balance. We need to break the cycle that equates all benefits to monetary increases. OpenAI may not have direct control over this, but they can enable or limit their product until necessary regulations and activities are implemented by governments to ensure that this revolution benefits the common good for everyone, rather than leading to destruction for many and benefits for few.
- **Threat: Privacy and data security at risk**
  Mitigating Action: This is a threat that is difficult to mitigate or eliminate since neither the AI itself nor its creators know the potential uses it may have with the data. The solution would involve evolving AI to identify and categorize data, as well as training it to forget certain information. While this is being achieved, the use of AI must be regulated, and the consequences of the information input into it must be communicated

4.9.3.7 Summary: Well-being group and SusAF analysis

Table 31 presents the summary of comparative analysis of different SusAF factors among participants from poor and good well-being groups. Based on qualitative analysis, enough evidence could not be found to support if participants from either of group has better broadness, depth or timescale analysis of sustainability effects. However, for synthesis, it was found that participants belonging to poor well-being group were able to convey actions better than those of good well-being group participants for both opportunities and threats.

Table 31: Summary of SusAF analysis comparison among participants of good and poor well-being

Factors (themes)	**Good**	**Poor**	**Inconc-lusive**	**Remarks**
Broadness (53)	4	2	48	Not enough evidence to support if participants from either of group has better broadness of effects
Depth (53)	12	12	30	Not enough evidence to support if participants from either of group has better depth of effects
Timescale (7)	2	-	5	Not enough evidence to support if participants from either of group has better timescale analysis
Synthesis	Among the actions that are conveyed well, participants from poor well-being group conveyed better than good well-being for both opportunities and threats			

4.10 Results for Sub RQ4: Well-being activities groups and SusAF Analysis

This section presents results to address the sub-research question **'Sub RQ4: What are the differences in the consideration of sustainability effects among group of participants based on their well-being practices?'**

In order to address the research question, this section contains the quantitative and qualitative analysis related to groups of participants based on well-being activities, breathing practices or meditation, and gymming (as presented in Table 18) and the metrics used in the factors of the SusAF analysis (Broadness, Depth, Timescale, and Synthesis).

4.10.1 Comparison among various well-being activities groups: Quantitative

For the quantitative analysis, right-tailed Wilcoxon rank sum test is used to check if there is any significant difference on the metrics of SusAF among the groups, as shown in Table 32.

Hypothesis definition: If groups based on '**activities**' indicate the groups based on well-being activities, breathing practices or meditation, and gymming separately, then for each metric (M) the general hypotheses for groups of participants based on activities are:

Null Hypothesis: "*There is no difference in value of metric (M) identified by groups of participants doing activities and not doing activities*", and
Alternative Hypothesis: "*The value of metric (M) for group where participants do activities is greater than that of the group where participants do not do activities*",

Table 32: Comparison of SusAF metrics within groups based on well-being activities, breathing practices or meditation, gymming done by participants

Metric	Well-being activities based group (p-value)	Breathing practices or meditation based group (p-value)	Gymming based group (p-value)
Broadness (n=30)			
No. of potential effects	0.568	0.231	0.784
No. of positive effects	0.671	0.688	0.975
No. of negative effects	0.412	**0.025***	0.297
Avg. No. of effects per dimension	0.568	0.231	0.784
Depth (n=27)			
No. of chains of effects	0.671	0.389	0.205
Avg. length of chains of effect	0.341	0.269	0.997
Timescale (n=30)			
No. of immediate effects	0.228	0.051	0.617
No. of enabling effects	0.373	0.138	0.407
No. of structural effects	0.551	0.126	0.982
Synthesis (n=30)			
No. of mitigating actions	0.259	**0.002***	0.161
No. of supporting actions	0.490	0.578	0.734

It is observed that there is no significant difference in all the metrics for the groups based on whether well-being activities are done by participants, as well as for the groups based on whether they do gymming, as observed p-values are greater than 0.05. However, **for groups based on breathing practices or meditation**, the p-value observed are less than 0.05 for one metric of broadness (**number of negative effects, p-value: 0.025**), and synthesis (**number of mitigating actions, p-value: 0.002**), signifying that we can **reject the null hypothesis for these metrics**, and conclude that the values for these metrics are greater among the group with participants who do breathing practices or meditation compared to the group where participants do not do breathing practices or meditation.

4.10.2 Well-being Activities Done and SusAF Analysis : Qualitative

This section presents qualitative comparison of SusAF results among participants from either of the two groups: those who do well-being activities, and those who do not, by qualitatively assessing the factors: broadness, depth, timescale and synthesis of effects identified. Table 33 presents the summary of classification of themes per dimension into groups based on whether well-being activities are done by participants belonging to the same theme. Quantitatively it can be seen that number of themes containing participants who do well-being activities is significantly higher than the number of themes containing participants who do not do well-being activities.

Table 33: Classification of themes per dimension based on well-being activities done by participants

Theme-based groups	**Social (32)**	**Individual (28)**	**Environmental (19)**	**Economic (29)**	**Technical (18)**	**Total (126)**
All participants do well-being activities	16	13	9	15	9	**62**
No participant does well-being activities	4	2	0	2	2	**10**
Mixed participants	12	12	10	13	7	**54**

4.10.2.1 Well-being Activities done and Broadness Analysis

Among 54 themes with mixed participants doing and not-doing well-being activities, broadness was observed better for participants who do well-being activities in 4 themes, for participants who do not do well-being activities in 1 theme, and for remaining 48 themes, the comparison results was inconclusive, as summarized in Table 34, indicating that number of inconclusive results were significantly higher, and the number of conclusive results are very less. Based on the qualitative analysis, no appropriate evidence was found to conclude if participants from either of group has better broadness analysis of effects.

Some examples of broadness among various themes and participants based on well-being activities done are presented below.

Theme: Benefits of Answers (n=5)
This theme had 5 participants with 3 participants doing activities for well-being and 2 not doing any activities. A participant who did well-being activities identified effect with high level of broadness, and all others identified effects with moderate level of broadness. As such, **better broadness was found for participant who did well-being activities** for this theme.

- (No activities done, Moderate Depth)
  – In competitions, people who use Chat-GPT have high - full answers
- (Activities done, High Depth)
  – If we use it to learn or understand about something, it would be very beneficial for human

Explanation: Here, participant who does not do well-being activities explain about benefits of having ChatGPT for some competitions (limited to competitions) where as the participant who do well-being activities indicate that Chat-GPT can benefit human, which seems broader and could incorporate various aspects

Theme: Improved task efficiency (n=4)
This theme had 4 participants where 2 participants who did well-being activities identified effect with moderate level of broadness,and 2 participants who did not do well-being activities identified effects with high level of broadness. As such, **better broadness was found for participant who did not do well-being activities** for this theme.

- (No activities done, High Depth)
  – Reduction in the probability of making errors in tasks
- (Activities done, Moderate Depth)
  – Efficiency in coding can assist programmers by providing solutions

Explanation: The effect identified by a participant who does not do well-being activities focuses on programming (limited scope), where as the one by a participant from who does well-being activities addresses broader scope, considering the probability of making errors can be for various field where programming can be one of them.

4.10.2.2 Well-being Activities done and Depth analysis

Among 54 themes containing mixed participants, depth was observed better for participants who do well-being activities in 16 themes, for participants who do not do well-being activities in 8 theme, and for remaining 30 themes, the comparison results was inconclusive, as summarized in Table 34. Quantitatively the number of themes where participants belong to the group that does well-being activities have better depth of theme compared to those of the participants who belong to the group that does not do well-being activities. However, there was not enough evidence and examples to conclude if participants belonging to either of these groups have better depths of analysis for SusAF results.

Some examples of depth among various themes and participants based on well-being activities done are presented below.

Theme: Information security issues (n=4)
Among 4 participants belonging to this theme, 2 of them did not do activities for well-being, and 2 of them did. Among them, 1 participant who did not do well-being activities identified effect with basic depth, and all other effects identified were of moderate level depth. As such, **better depth was found for participant who did well-being activities** for this theme.

- (No activities done, Basic Depth)
  – Users might share personal information not thinking about the security
- (Activities done, Moderate Depth)
  – AI may have access to personal information. If not properly managed, there is a risk of privacy breaches or data falling into the wrong hands, which could have negative consequences for users

Explanation: The participant who does not do well-being activities only mentions about sharing information without thinking about security, where as the participant who does well-being activities presents about the risk associated and possibility of negative consequences for users (better depth)

Theme: Impact on Employment (n=23)
Among 23 participants belonging to this theme, 5 of them did not do any activities for well-being and had identified effects with basic level of depth. From remaining 18 participants, 9 identified effects had moderate level of depth, and 9 had basic level depth. As such, **better depth was found for participants who did well-being activities** for this theme.

- (No activities done, Basic Depth)
  – ChatGPT already replaces most work within CRM in many company
- (Activities done, Moderate Depth)
  – ChatGPT can reduce monetary value by increasing unemployment and replacing humans

Explanation: Here the participant who does well-being activities presents the impact of replacing humans on reducing the monetary value (better depth), which is not mentioned by the participant who does not do wellbeing activities.

Theme: Reliability and Authenticity (n=4)
Among 4 participants of this theme, 3 did well-being activities, and 1 did not. The participant who did not do activities had identified effect with moderate level of depth, and among 3 participants, 2 effects were basic level, and 1 was moderate level. However, when comparing the result of participants related to misinformation, **participant who did not do well-being activities had better depth analysis**.

- (No activities done, Moderate Depth)
  – Spread of misinformation: There is a percentage of inaccuracy regarding the provided information since it is based on data only up to 2021. This can have a negative impact on decision-making and users' understanding
- (Activities done, Basic Depth)
  – Spread of fake news or unreliable information

Explanation: Here the participant who does not do well-being activities provides in-depth details about data being based up to 2021 and the possible negative impacts.

4.10.2.3 Well-being Activities done and Timescale analysis

Among 29 themes for structural effects, 21 themes had participants who do well-being activities, and 5 themes had participants who do not do any well-being activities. As such, only 3 themes had mixed participants. Quantitatively, it can be seen that the themes where participants do well-being activities has higher number of moderate richness for timescale analysis. However, for the themes with mixed participants, qualitatively, no conclusion could be made if participants from either of the groups has better timescale analysis of SusAF results.

Some examples of the effects along with the richness of structural effects are presented below.

Theme: Impact on Employment (n=11)
Among 11 structural effects correctly identified in this theme, 8 of them were from participants who did well-being activities (7 basic richness, 1 moderate richness) and 3 from those with did not do well-being activities (3 basic richness). However, on comparison, the **timescale factor was inconclusive** for this theme. Some examples of the effects identified by the participants are as follows:

- (Activities done, Basic Richness)
  – Extinction of some professions
- (Activities not done, Basic Richness)
  – Disappearance of trades and jobs

The participants from poor well-being group and good well-being groups have similar richness for these structural effects. They are simply stated and lack explanations and supporting details

Theme: Inequity and Inequality in Society (n=4)
Among 4 structural effects correctly identified in this theme, 2 of them were from participants who did well-being activities (1 basic richness, 1 moderate richness) and 2 from those with did not do well-being activities (1 basic richness, 1 moderate). On comparison, the **timescale factor was inconclusive** for this theme. Some examples of the effects identified by the participants are as follows:

- (Activities done, Basic Richness)
  – Inequality based on social status, gender, race, religion
- (Activities not done, Basic Richness)
  – Possibility of amplifying gender or race biases

Similar to above, the richness is basic for both as they lack explanation and supporting details.

4.10.2.4 Well-being Activities done and Synthesis Analysis

This section makes qualitative comparison of how well the actions to support opportunities and mitigate threats are conveyed among the participants who do well-being activities and do not do well-being activities.

Opportunities and Supporting Actions: Among 40 supporting actions, 33 participants did activities for well-being and 7 did not do any activities for their well-being. While some participants from both the groups had conveyed the actions properly, no conclusion could be made to say if participants from either of the groups had better synthesis analysis of the actions.

Some examples of opportunities and supporting actions by participants doing or not doing well-being activities are presented below.

Properly conveyed supporting actions for opportunities by participants who did well-being activities

- **Opportunity: Greater efficiency and effectiveness of workers**
  Supporting Action: It is necessary to train workers in the use of ChatGPT so that they can make the most of it without compromising sensitive data.
- **Opportunity: Access to information: Allows quick access to a wide range of information on various topics, facilitating learning and increasing users' knowledge.**
  Supporting Action: OpenAI should expand the coverage of topics, improve the accuracy of responses, and address misinformation and biases. It can also collaborate with experts and communities, provide documentation and educational resources, and explore options for translation and multilingualism. These actions would ensure broader and more reliable access to information through ChatGPT and provide up-to-date information as of 2023.

Properly conveyed supporting actions for opportunities by participants who did not do well-being activities

- **Opportunity: Improvement in production tasks that can be performed by AI**
  Supporting Action: There are many tasks that can be optimized using AI, providing greater efficiency to companies. Actions to take would be adopting this technology in different areas where behavior is entirely analytical and does not involve emotional or ethical biases, always under supervision and training of a person. Therefore, as a company, we need to make known and explain the ethical and social limitations of this tool and promote its more analytical and assisting/facilitating use. Training individuals to transition from operators to verifiers, prompters, or quality managers of the work.

Threats and Mitigating Actions: Among 88 mitigating actions, 72 of there were identified by participants who did well-being activities, and 16 were identified by participants who did not do well-being activities. Some participants who did well-being activities and some of

them who did not do well-being activities conveyed corresponding actions properly, however qualitatively, no conclusion could be made if participants from either of the groups had better synthesis analysis.

Some examples of threats and mitigating actions by the participants are given below.

Properly conveyed mitigating actions for threats by participants who did well-being activities

- **Threat: Replacing jobs in certain areas**
  Mitigating Action: Establish retraining and training programs to facilitate employees' transition to new job opportunities and growing sectors..
- **Threat: Privacy and data security: AI may have access to personal information. If not properly managed, there is a risk of privacy breaches or data falling into the wrong hands, which could have negative consequences for users.**
  Mitigating Action: OpenAI should implement robust security measures, comply with privacy regulations, and enable user control and consent over their data. Additionally, they should conduct security assessments, promote privacy education, and ensure transparency in their data handling practices. These steps are crucial to protect user privacy, maintain data security, and build trust with users regarding the handling and usage of their personal information.

Properly conveyed mitigating actions for threats by participants who did not do well-being activities

- **Threat: Privacy and data security at risk.**
  Mitigating Action: This is a threat that is difficult to mitigate or eliminate since neither the AI itself nor its creators know the potential uses it may have with the data. The solution would involve evolving AI to identify and categorize data, as well as training it to forget certain information. While this is being achieved, the use of AI must be regulated, and the consequences of the information input into it must be communicated.

4.10.2.5 Summary: Well-being activities done and SusAF analysis

Table 34 presents the summary of comparative analysis of different SusAF factors among participants who did well-being activities and did not do well-being activities. It can be seen that enough evidence could not be found to support if participants belonging to either of the groups have better broadness, depth, timescale, or synthesis analysis.

Table 34: Summary of SusAF analysis among participants based on well-being activities done

Factors (themes)	Activities done	Activities not done	Incon-clusive	Remarks
Broadness (53)	4	1	48	Not enough evidence to support if participants from either of group has better broadness analysis
Depth (53)	16	7	30	Not enough evidence to support if participants from either of group has better depth analysis
Timescale (3)	2	-	2	Not enough evidence to support if participants from either of group has better timescale analysis
Synthesis (128 effects)	Not enough evidence to support if participants from either of group has better synthesis analysis for both opportunities and threats			

4.10.3 'Breathing exercises or Meditation' and SusAF Analysis : Qualitative

This section presents qualitative comparison of SusAF results among participants belonging to either of two groups: those who do breathing exercises or meditation and those who do not, by qualitatively assessing the factors: broadness, depth, timescale and synthesis of effects identified. Table 35 presents the summary of classification of themes per dimension into groups based on whether breathing exercises or meditation are done by participants belonging to the same theme. Quantitatively it can be seen that number of themes containing participants who do not do breathing exercises or meditation is significantly higher than the number of themes containing participants who do breathing exercises or meditation.

Table 35: Classification of themes per dimension based on breathing exercises or meditation done by participants

Theme-based groups	Social (32)	Individual (28)	Environmental (19)	Economic (29)	Technical (18)	Total (126)
All participants do breathing exercises or meditation	6	2	2	5	4	**19**
No participant does breathing exercises or meditation	15	10	3	13	7	**48**
Mixed participants	11	16	14	11	7	**59**

4.10.3.1 'Breathing exercises or Meditation' and Broadness Analysis

Among 59 themes with mixed participants, broadness was observed better for participants who do breathing exercises or meditation in 2 themes, for participants who do not do these activities in 1 theme, and for remaining 56 themes, the comparison results was inconclusive, as summarized in Table 36. It can be seen that the number of conclusive results are very less. Based on the qualitative analysis, no appropriate evidence was found to conclude if participants from either of group has better broadness analysis of effects.

Some examples of broadness among various themes and participants based on breathing exercises or meditation done by them are presented below.

Theme: Reduce Waste, Energy, and resources (n=8)
Among 8 effects belonging to this theme, 2 of them were identified by participants who did breathing exercises or meditation for their well-being (2 high broadness), and remaining 6 were identified by participants who did not do breathing exercises or meditation (6 moderate broadness). As such, **broadness for this theme was better for participants who did breathing exercises or meditation.**

- (No breathing exercises or meditation done, Moderate Broadness)
  – ChatGPT could help reduce waste and pollution by fact checking wrong claim about climate change
- (Breathing exercises or meditation done, High Broadness)
  – Reduction of the carbon footprint

Explanation: A participant who does not do breathing exercises or meditation focuses on fact checking on claim about climate change to help reduce waste and pollution (limited to fact checking), where as a participant from who did not do this activity focuses on reduction of carbon footprint which seems to have wider coverage

Theme: Improved task efficiency (n=4)
Among 4 effects belonging to this theme, 1 of them were identified by participant who did breathing exercises or meditation for their well-being (1 moderate broadness), and remaining 3 were identified by participants who did not do breathing exercises or meditation (1 moderate broadness, 3 high broadness). As such, **broadness for this theme was better for participants who did not do breathing exercises or meditation.**

- (Breathing exercises or meditation done, Moderate Broadness)
  – Efficiency in coding can assist programmers by providing solutions
- (No breathing exercises or meditation done, High Broadness)
  – Reduction in the probability of making errors in tasks

Explanation: The effect identified by a participant who does not do breathing exercises or meditation focuses on programming (limited scope), where as the one by a participant from other group addresses broader scope, considering the probability of making errors can be for various field where programming can be one of them.

4.10.3.2 'Breathing exercises or Meditation' and Depth analysis

Among 59 themes with mixed participants, depth was observed better for participants who do breathing exercises or meditation in 3 themes, for participants who not do these activities in 13 themes, and for remaining 43 themes, the comparison results was inconclusive, as summarized in Table 36.

Quantitatively the number of themes where participants belong to the group that does not do breathing exercises or meditation is higher than the number of themes where participants belong to the group that does breathing exercises or meditation. Also, qualitatively, the effects identified by participants belonging to the group that does not do breathing exercise or mediation were found to be better than those identified by participants from other group.

Some some examples of depth among various themes and participants based on well-being activities done are presented below.

Theme: Reliability and Authenticity (n=4)
Among 4 effects belonging to this theme, 3 of them were identified by participants who did breathing exercises or meditation for their well-being (2 basic depth, 1 moderate depth), and 1 was identified by participant who did not do breathing exercises or meditation (1 moderate depth). On comparison about spread of misinformation, **depth was found to be better for the participant who did not do breathing exercises or meditation.**

- (No breathing exercises or meditation done, Moderate Depth)
  – Spread of misinformation: There is a percentage of inaccuracy regarding the provided information since it is based on data only up to 2021. This can have a negative impact on decision-making and users' understanding.
- (Breathing exercises or meditation done, Basic Depth)
  – Spread of fake news or unreliable information

Explanation: Here, the effect identified by participant who does breathing exercises or meditation is basic and simple statement, where as the effect identified by participant from another group provides in depth detail of information being based on data until 2021, and possible negative impacts due to spread of misinformation (higher depth).

Theme: Impact on Employment (n=23)
Among 23 effects belonging to this theme, 8 of them were identified by participants who did breathing exercises or meditation for their well-being (5 basic depth, 3 moderate depth), and 15 were identified by participant who did not do breathing exercises or meditation (9 basic depth, 6 moderate depth). However, on comparison about spread of misinformation, **depth was found to be better for the participant who did breathing exercises or meditation.**

- (No breathing exercises or meditation done, Basic Depth)
  – Job Loss of employees
- (Breathing exercises or meditation done, Moderate Depth)
  – ChatGPT can reduce monetary value by increasing unemployment and replacing humans

Explanation: Here the participant from the group that does not do breathing exercises or meditation simply mentions about job loss, where as the one from group that does these activities mentions about reduction in monetary value due to unemployment (better depth).

Theme: Impact of Biased Information (n=3)
Among 3 effects belonging to this theme, 2 of them were identified by participants who did breathing exercises or meditation for their well-being (2 moderate depth), and 1 was identified by participant who did not do breathing exercises or meditation (1 high depth). Overall, **depth was found to be better for the participant who did not do breathing exercises or meditation.**

- (No breathing exercises or meditation done, High Depth)
  – Dependency: Since this is a website programmed by individuals, there is a possibility that it reflects or influences people's decisions based on preloaded ideologies. This can lead to biased responses or recommendations in terms of gender, race, or other aspects, which could be harmful and discriminatory.
- (Breathing exercises or meditation done, Moderate Depth)
  – Users can be affected by biased information which is normal and the users can not do anything about it or blame the product

Explanation: Here the participant who does not do breathing exercises or meditation has better in depth explanation for the cause of the biased response as well as its possible impact, where as participant who does breathing exercises or meditation only mentions the impact of the effect identified.

4.10.3.3 'Breathing exercises or meditation' done and Timescale analysis

Among 29 themes for structural effects, 9 themes had participants who do breathing exercises or meditation, 16 themes had participants who do not do breathing exercises or meditation, and only 4 themes had mixed participants. Quantitatively, it was observed that the themes where participants do not do breathing exercises or meditation has higher number of moderate richness for timescale analysis. However, for the themes with mixed participants, qualitatively, no conclusion could be made if participants from either of the groups have better timescale analysis of SusAF results, as summarized in Table 36.

Some examples of the effects with the richness of structural effects are presented below.

Theme: Impact on Employment (n=11)
Among 11 structural effects correctly identified in this theme, 5 of them were from participants who did breathing exercises or meditation (4 basic richness, 1 moderate richness) and 6 from those with did not do breathing exercises or meditation (6 basic richness). On comparison, the **timescale factor was inconclusive** for this theme. Some examples of the effects identified by the participants are as follows:

- (Activities done, Basic Richness)
  – Extinction of some professions
  - Increase in unemployment
- (Activities not done, Basic Richness)
  – Disappearance of trades and jobs

Participants belonging to both groups have similar richness for these structural effects where they simply state the effects, and lack explanations or supporting details.

Theme: Lower Trust (Society) (n=3)
Among 3 structural effects correctly identified in this theme, 2 of them were from participants who did breathing exercises or meditation (1 basic richness, 1 moderate richness) and 1 was from the participant with did not do breathing exercises or meditation (1 basic richness). The **timescale factor was found better for participants who did breathing exercises or meditation** for this theme. Some examples of the effects identified by the participants are as follows:

- (Activities done, Moderate Richness)
  – If we use it as a worker or make it do a job for you which we really don't understand the output, or just use the output from the ChatGPT, it would affect the trust among humanity
- (Activities not done, Basic Richness)
  – Lack of Trust

A detailed explanation can be seen in effect identified by participant who does breathing exercises or meditation, as compared to the one who does not as it has basic richness in the statement.

4.10.3.4 'Breathing exercises' or meditation done and Synthesis Analysis

This section makes qualitative comparison of how well the actions to support opportunities and mitigate threats are conveyed among the participants who do breathing exercises or meditation and those who do not.

Opportunities and Supporting Actions: Among 40 supporting actions, 17 participants did breathing exercises or meditation while 23 of them did not. While some participants from both the groups separately had conveyed the actions properly, based on the qualitative analysis, the participants who did not do breathing exercises or meditations had conveyed those actions in comparatively better way.

Some examples of opportunities and supporting actions by participants doing or not doing breathing exercises or meditation are presented below.

Properly conveyed supporting actions for opportunities by participants who did breathing exercises or meditation

- **Opportunity: Creating new business models based on the use of ChatGPT (plugins or APIs) workers**
  Supporting Action: Promote collaboration with developers and companies to create plugins and APIs that allow the integration of ChatGPT into variou applications and services.

Properly conveyed supporting actions for opportunities by participants who did not do breathing exercises or meditation

- **Opportunity: Inclusion and diversity: It should be inclusive of all users, including those with disabilities.**
  Supporting Action: OpenAI should consider including voice command functionalities to ensure accessibility for blind or visually impaired individuals. This would allow these individuals to interact and obtain information through ChatGPT in a more accessible and inclusive manner, facilitating their participation and user experience.
- **Opportunity: Quick access to information and knowledge**
  Supporting Action: The company should engage in a continuous effort to improve the algorithms that search and process information in order to select reliable sources and disregard unverified sources.
- **Opportunity: Improvement in production tasks that can be performed by AI.**
  Supporting Action: There are many tasks that can be optimized using AI, providing greater efficiency to companies. Actions to take would be adopting this technology in different areas where behavior is entirely analytical and does not involve emotional or ethical biases, always under supervision and training of a person. Therefore, as a company, we need to make known and explain the ethical and social limitations of this tool and promote its more analytical and assisting/facilitating use. Training individuals to transition from operators to verifiers, prompters, or quality managers of the work.

Threats and Mitigating Actions: Among 88 mitigating actions, 47 of them were identified by participants who did breathing exercises or meditation, and 41 were identified by participants who did not do breathing exercises or meditation. On qualitatively assessing the mitigating actions, the participants who did not do breathing exercises or meditation had conveyed the mitigating actions in better way than the participants from other group.

Some examples of threats and mitigating actions by the participants are shown below.

Properly conveyed mitigating actions for threats by participant who did breathing exercises or meditation

- **Threat: Replacing jobs in certain areas**
  Mitigating Action: Establish retraining and training programs to facilitate employees' transition to new job opportunities and growing sectors.
- **Threat: Spread of fake news or unreliable information**
  Mitigating Action: Implement mechanisms for verification and validation of information generated by ChatGPT, such as the inclusion of truth labels or identification of reliable sources.

Properly conveyed mitigating actions for threats by participant who did not do breathing exercises or meditation

- **Threat: Privacy and data security: AI may have access to personal information. If not properly managed, there is a risk of privacy breaches or data falling into the wrong hands, which could have negative consequences for users.**
  Mitigating Action: OpenAI should implement robust security measures, comply with privacy regulations, and enable user control and consent over their data. Additionally, they should conduct security assessments, promote privacy education, and ensure transparency in their data handling practices. These steps are crucial to protect user privacy, maintain data security, and build trust with users regarding the handling and usage of their personal information.
- **Threat: Loss of critical thinking skills**
  Mitigating Action: The company can offer, especially to schools, training workshops explaining how to correctly use its application, its limitations and the need to check With reliable sources.
- **Threat: Disclosure of dangerous information: It is possible for AI to provide information that is potentially harmful or dangerous to users. This may include instructions or advice that could result in physical harm, promotion of illegal or dangerous activities, or disclosure of sensitive personal data.**
  Mitigating Action: OpenAI should consider implementing continuous training and supervision, implementing safety filters, feedback mechanisms, and user reporting, human review, and education on responsible use. These measures would help ensure the system's ongoing improvement, enhance safety, address potential issues, and promote responsible and ethical usage of ChatGPT.

4.10.3.5 Summary: Breathing exercises or meditation done and SusAF analysis

Table 36 presents the summary of comparative analysis of different SusAF factors among groups based on breathing exercises or meditation done. As it can be seen, there was not enough evidence to make conclusion on participants from which of the two groups had better broadness and timescale, where as the participants from the group who did not do breathing exercises or meditation were found to have better depth and synthesis analysis.

Table 36: Summary of SusAF analysis among participants based on breathing exercises or meditation done

Factors (themes)	Breathing exercises or meditation done	Breathing exercises or meditation not done	Inconclusive	Remarks
Broadness (59)	2	1	56	Not enough evidence to support if participants from either of group have better broadness analysis
Depth (59)	3	13	43	Participants belonging to the group who did not do breathing exercises or meditation were found to have slightly better depth analysis
Timescale (4)	1	-	3	Not enough evidence to support if participants from either of group have better timescale analysis
Synthesis (128 effects)	Some participants belonging to the group who did not do breathing exercises or meditation were found to have better synthesis analysis			

4.10.4 Gymming and SusAF Analysis : Qualitative

This section presents qualitative comparison of SusAF results among participants from either of two groups: those who do gymming and those who do not, by qualitatively assessing the factors: broadness, depth, timescale and synthesis of effects identified by the participants. Table 37 presents the summary of classification of themes per dimension into groups based on whether gymming is done by participants belonging to the same theme effects. Quantitatively it can be seen that number of themes containing participants who do not do gymming is significantly higher than the number of themes containing participants who do gymming.

Table 37: Classification of themes per dimension based on gymming done by participants

Theme-based groups	Social (32)	Individual (28)	Environmental (19)	Economic (29)	Technical (18)	Total (126)
All participants do gymming	3	5	2	4	2	**16**
No participant does gymming	14	7	4	9	10	**44**
Mixed participants	15	16	13	16	6	**66**

4.10.4.1 Gymming and Broadness Analysis

Among 66 themes with mixed participants, broadness was observed better for participants who do and do not do gymming in 2 themes each, and for remaining 62 themes, the comparison results was inconclusive, as summarized in Table 38. It can be seen that the number of

conclusive results are very less. Based on the qualitative analysis, no appropriate evidence was found to conclude if participants from either of group has better broadness analysis of effects.

Some examples of broadness among various themes and groups of participants based on gymming done by them are presented below.

Theme: Benefits of Answers (n=5)
Among 5 effects belonging to this theme, 3 were identified by participants who did gymming (2 moderate broadness, 1 high broadness), and 2 were identified by participants who did not do gymming (2 basic broadness). The broadness was better for participant from the group that did gymming. Examples of some effects for participants in this group are as follows:

- (No gymming done, Moderate Broadness)
  – In competitions, people who use Chat-GPT have high - full answers
- (Gymming done, High Broadness)
  – If we use it to learn or understand about something, it would be very beneficial for human.

Explanation: Here the participant who does not do gymming mentions the benefits of ChatGPT to some competitions, where as the participant who does gymming mentions about it being beneficial for human which seems much broader.

Theme: Impact of Biased Information (n=3)
Among 3 effects belonging to this theme, 2 were identified by participants who did gymming (1 moderate broadness, 1 high broadness), and 1 was identified by participant who did not do gymming (1 moderate broadness). The broadness was better for participant from the group that did not do gymming. Examples of some effects for participants in this group are as follows:

- (No gymming done, High Broadness)
  – Dependency: Since this is a website programmed by individuals, there is a possibility that it reflects or influences people's decisions based on preloaded ideologies. This can lead to biased responses or recommendations in terms of gender, race, or other aspects, which could be harmful and discriminatory.
- (Gymming done, Moderate Broadness)
  – ChatGPT only knows what the user enters, and has therefore highly limited capability to give suggestions about individual health. This is usually known to the user though.

Explanation: Here the effect identified by participant who does not do gymming mentions the impact of information on individual health (limited scope) as compared to the one mentions on broader scope.

4.10.4.2 Gymming and Depth Analysis

Among 66 themes with mixed participants, depth was observed better for participants who do gymming in 9 themes, for participants who not do gymming in 8 themes, and for remaining 49 themes, the comparison results was inconclusive, as summarized in Table 38. Qualitatively,

no significant evidence was found to conclude if participants from either of the groups has better depth of analysis for SusAF results.

Some examples of depth among various themes and participants based on gymming done are shown below.

Theme: Energy by Hardware and Infrastructure (n=13)
Among 13 effects belonging to this theme, 3 were identified by participants who did gymming (1 high depth, 2 basic depth), and 10 were identified by participants who did not do gymming (1 moderate depth, 9 basic depth). On comparision, the depth was better for participant from the group that did gymming. Examples of some effects for participants in this group are as follows:

- (No gymming done, Basic Depth)
  – May affect on waste and energy consumption due to data center
  - Emissions will be on greater extent from its data centers
- (Gymming done, High Depth)
  – Consumes lots of energy via servers and data centers for service resides. To produce the energy, fossil fuels or coals need to be burned, which results in waste and pollution.

Explanation: Here, the effects identified by participants who do not do gymming are basic and simple statement, where as the effect identified by participant who does gymming provides some details about source of production of energy resulting in waste and pollution (higher depth)

Theme: Better Value (n=3)
Among 3 effects belonging to this theme, 1 was identified by a participant who did gymming (1 moderate depth), and 2 were identified by participants who did not do gymming (1 moderate depth, 1 basic depth). On comparision, the depth was better for participant from the group that did not do gymming. Examples of some effects for participants in this group are as follows:

- (No gymming done, Moderate Depth)
  – Create value for business because it could replace a lot of admin work and company can work more efficient as one person can do lot more workload with help of ChatGPT
- (Gymming done, Moderate Depth)
  – Increases value by providing services in all fields.

Explanation: Here, both the participants mentions about value provided by ChatGPT, but the one listed by participant who does not do gymming has comparatively detailed explanation that the participant who does gymming.

4.10.4.3 Gymming and Timescale Analysis

Among 29 themes for structural effects, 3 themes had participants who do gymming, 22 themes had participants who do not do gymming, and only 4 themes had mixed participants. Quantitatively, the number of themes with participants belonging to gymming group has less moderate level of richness compared to the ones belonging to the non-gymming group.

However, for the 4 themes with mixed participants, no evidence could be found to conclude if participants from either of the group has better timescale analysis.

Theme: Impact on Employment (n=11)
Among 11 effects belonging to this theme, 2 were identified by participant who did gymming (1 moderate richness, 1 basic richness), and 9 were identified by participants who did not do gymming (9 basic depth richness). On comparision, the richness of structural effects was found to be similar among participants who did and did not do gymming. Examples of some effects for participants in this group are as follows:

- (No gymming done, Basic richness)
  – Extinction of some professions
  Disappearance of trades and jobs
- (Gymming done, Basic richness)
  – Will make many jobs disappear (people will have to adapt).

Explanation: Participants belonging to both groups have similar richness for these structural effects where they simply state the effects, and lack explanations or supporting details.

Theme: Lower Trust (Society) (n=3)
Among 3 effects belonging to this theme, 2 were identified by a participant who did gymming (1 moderate richness, 1 basic richness), and 1 was identified by participant who did not do gymming (1 basic depth). On comparision, the richness was better for the participant who did gymming. Examples of some effects for participants in this group are as follows:

- (No gymming done, Basic richness)
  – Lack of Trust
- (Gymming done, Moderate richness)
  – If we use it as a worker or make it do a job for you which we really don't understand the output, or just use the output from the ChatGPT, it would affect the trust among humanity.

Explanation: A detailed explanation can be seen in effect identified by participant who does gymming, as compared to the one who does not as it has basic richness in the statement.

4.10.4.4 Gymming and Synthesis Analysis

This section presents results of qualitative comparison of how well the actions to support opportunities and mitigate threats are conveyed among the participants who do gymming and those who do not.

Opportunities and Supporting Actions: Among 40 supporting actions, 12 participants did gymming while 28 of them did not. Based on the qualitative analysis, the participants who did not do gymming had conveyed those actions in comparatively better way than those who did gymming.

Some examples of opportunities and supporting actions by participants doing or not doing gymming are shown below.

Properly conveyed supporting actions for opportunities by participants who did gymming

- **Opportunity: More people use it for all purpose tasks like summarizing, generating, outlining**
  Supporting Action: Mitigating biases and enabling users to think about individual problems themselves, chat GPT can be highly helpful for general purpose decision support / textual processing.

Properly conveyed supporting actions for opportunities by participants who did not do gymming

- **Opportunity: Creating new business models based on the use of ChatGPT (plugins or APIs)**
  Supporting Action: Promote collaboration with developers and companies to create plugins and APIs that allow the integration of ChatGPT into various applications and services.
- **Opportunity: Inclusion and diversity: It should be inclusive of all users, including those with disabilities.**
  Supporting Action: OpenAI should consider including voice command functionalities to ensure accessibility for blind or visually impaired individuals. This would allow these individuals to interact and obtain information through ChatGPT in a more accessible and inclusive manner, facilitating their participation and user experience.
- **Opportunity: Quick access to information and knowledge**
  Supporting Action: The company should engage in a continuous effort to improve the algorithms that search and process information in order to select reliable sources and disregard unverified sources.

Threats and Mitigating Actions: Among 88 mitigating actions, 42 of them were identified by participants who did gymming, and 46 were identified by participants who did not do gymming. On qualitatively assessing the mitigating actions, the participants who did not do gymming had conveyed the mitigating actions in better way than the participants from other group.

Some examples of threats and mitigating actions identified by the participants are as follows.

Properly conveyed mitigating actions for threats by participants who did gymming

- **Threat: A huge model required and an extensive training required which will generate e-waste and co2 emissions**
  Mitigating Action: More sustainable coding practices / compressing data / making infrastructures more sustainable.

Properly conveyed mitigating actions for threats by participants who did not do gymming

- **Threat: Loss of critical thinking skills**
  Mitigating Action: The company can offer, especially to schools, training workshops explaining how to correctly use its application, its limitations and the need to check With reliable sources.
- **Threat: Spread of fake news or unreliable information**
  Mitigating Action: Implement mechanisms for verification and validation of information generated by ChatGPT, such as the inclusion of truth labels or identification of reliable sources.
- **Threat: Replacing jobs in certain areas**
  Mitigating Action: Establish retraining and training programs to facilitate employees' transition to new job opportunities and growing sectors.

4.10.4.5 Summary: Gymming done and SusAF analysis

Table 38 presents the summary of comparative analysis of different SusAF factors among groups based on gymming done.

Table 38: Summary based on gymming done and SusAF analysis comparison

Factors (Comparable themes)	**Gymming done**	**Gymming not done**	**Inconclusive**	**Remarks**
Broadness (66)	2	2	62	Not enough evidence to support if participants from either of group has better broadness analysis
Depth (66)	9	8	49	Not enough evidence to support if participants from either of group has better depth analysis
Timescale (4)	1	-	3	Not enough evidence to support if participants from either of group has better timescale analysis
Synthesis (128 effects)	Some participants who did not do gymming were found to have better synthesis analysis			

5 Discussion

This chapter provides an interpretation of the findings based on the results for each research question. Furthermore, threats to validity and future works will be explored.

5.1 Results interpretation

This thesis study investigates the potential relationship well-being and sustainability mindset among a sample of IT students. To explore the well-being of participants, three standard instruments were used: WHO-5, PWB, and SWLS. The sustainability mindset of the participants were explored by assessing their belief, attitude, and intention towards sustainability, and their consideration for sustainability effects of IT products and services, which is obtained from SusAF analysis on Chat-GPT. Also, comparative analysis was done among participants belonging to different groups based on their well-being practices and their sustainability mindset.

This section presents a detailed analysis on the findings from the results and their implications with respect to the sub research questions of the study.

5.1.1 Discussion Sub RQ1: Relationship of well-being of IT students with their belief, attitude, and intention towards sustainability.

Based on the Kendall's correlation test, there was no statistically significant correlation between well-being scores from different instruments, and statements related to belief, attitude, and intention towards sustainability. For most of the statements, the participants had higher mean scores, despite having different well-being scores. Also, when comparing the scores among participants from good and poor well-being using Wilcoxon rank sum test, no significant difference was found among these two groups for all statements related to belief, attitude and intention (except one statement for intention, I5: I will participate in campaigns/causes that promote sustainable development). It was found that participants with good well-being groups were more willing to participate in campaigns/causes that promote sustainable development. However, among a total of 25 statements combined, the difference was found only in the one statement related to intention, overall implying that both groups have similar belief, attitude, and intention towards sustainability. This indicates lack of evidence to say that well-being might affect an individual's belief, attitude, and intention towards sustainability.

Addressing related works: Some of the studies presented positive correlation between Subjective well-being (SWB) and aspects related to environmental sustainability such as Ecolog-

ically responsible behavior (ERB) [44], Ecologically sustainable behavior (ESB) [10] and Pro-environmental behavior (PEB) [9]. However, the thesis study is unable to support this, as participants' scores for belief, intention and attitude statements related to environmental aspects of sustainability were higher irrespective of their well-being, giving an indication that well-being might not be correlated with these aspects of environmental sustainability. For examples, for a belief statement B1 (I feel more morally obliged to do something about environmental problems), the mean value was 4.2, for an attitude statement A2 (I am more concerned about environmental pollutions), the mean value was 4.067, and for intention statement I1 (I prefer to work for an environmentally responsible employer in the future), the mean score was 4.4, indicating higher scores for these statements irrespective of difference in well-being among participants.

A study presented that higher levels of well-being is related to adoption of a more sustainable lifestyle [43]. In this thesis study, a statement of intention (I3: I intend to change/continue to change my lifestyle for better sustainability) highlighted if participants intend to adopt a more sustainable lifestyle. The mean value for this statement was 4.367 indicating that participants had high intention to adopt a more sustainable lifestyle, irrespective of their well-being level, failing to demonstrate enough evidence to support the relationship of well-being and adoption of sustainable lifestyle. Similarly, this thesis study could not support the research findings of sustainable values and attitudes being associated with higher well-being [45], as the correlations between well-being and belief, attitude and intention was found to be insignificant for most of the statements.

This inability to support findings from various studies, as well as the results of no correlation of well-being with belief, attitude and intention towards sustainability is highly influenced by the smaller sample size of the participants in this study. Also, it is to be considered that most of the participants are familiar with sustainability through various sources, and they seem to have a better understanding on the importance of sustainability, which is shown by their scores for various statements of belief, attitude, and intention towards sustainability. Along with this, most of the participants were students of the Software Engineers for Green Deal program who have been taught about sustainability in certain depth.

5.1.2 Discussion Sub RQ2: Differences in belief, attitude, and intention towards sustainability among different groups of participants based on their well-being practices.

Based on whether the participants do well-being activities, do breathing exercises or meditation, and do gymming, two groups were made for each category, and comparative analysis was done for each category among two groups to find out if there is any statistical difference of the scores for belief, attitude, and intention towards sustainability. For the well-being

activities based groups and breathing exercises or meditation based groups, no significant difference was found, whereas for gymming based groups, significant difference was found for one statement for Attitude (A11: I make an effort to use energy and resources more efficiently) and a statement for Intention (I2: I prefer to work for a socially responsible employer in the future). However, no evidence was found to conclude if the group that does gymming has better scores that the group that does not do gymming. Not having a significant difference among various groups of participants is logical as the participants seem to be well aware about the importance of sustainability through various sources, and have similar higher scores for various statements of belief, attitude and intention towards sustainability, independent of whether they do well-being activities, breathing exercises or meditation, and gymming. As such, the results also indicate lack of evidence to claim that doing these activities might affect participant's belief, attitude, and intention towards sustainability.

Addressing related works: Various researches show positive association of mindfulness with motivation for climate adaptation actions [7], planetary well-being [10], sustainable food consumption [10] and social sustainability at organizational level [50]. As there was lack of evidence to claim that the group doing breathing exercises or meditation had better scores for belief, attitude and intention towards sustainability, a claim could not be about the positive association found by these different researches. Overall, participants had higher scores for belief, attitude and intention statements irrespective of whether they did breathing exercises or meditation. As such the failure of supporting the claims by research is highly influenced by a small sample of participants, and their familiarity with sustainability.

5.1.3 Discussion Sub RQ3: Relationship of well-being of the students with their consideration for sustainability effects of software products and services.

To address this sub-research question, correlation analysis was carried out among well-being scores (WHO-5, PWB, SWLS) of participants with various metrics for each factor (broadness, depth, timescale, and synthesis) of SusAF analysis, along with comparison on the metrics among good and poor well-being groups.

The results presented a lack of statistically significant correlation between well-being scores (WHO-5, PWB, SWLS) and the metrics of SusAF factors, indicating lack of evidence to claim that well-being scores of participants might affect any particular metric of the SusAF analysis.

Further comparison of the metrics between poor and good well-being groups of participants was done using the right-tailed Wilcoxon test, and the values were found to be significantly higher only for one metric of broadness (number of negative effects), and one metric of timescale (number of immediate effects) favoring good well-being group. However, for all

other metrics there was no significant difference found between the groups. As a result of this, no conclusion could be made about which group has better SusAF analysis quantitatively.

Additionally, the qualitative analysis did not provide conclusive evidence to support if participants from either groups had better broadness, depth and timescale analysis of effects. For some of the themes, the effects listed by the participants were almost the same among participants with good and poor well-being, and for the majority of the themes they had similar levels of broadness and depth, and hence failed to provide conclusive supporting evidence. In the case of timescale analysis, more than half of the structural effects identified had basic richness, and the remaining had moderate richness. Also, among these effects with moderate levels of richness, no strong evidence was found to conclude if participants belonging to either of the groups had better richness of the structural effects identified.

However, on comparing the corresponding actions for opportunities and threats, the participants with poor well-being conveyed them better than participants with good well-being. Interestingly, some of the participants with poor well-being had detailed and better explanations about the possible actions to support opportunities and mitigate threats, enabling us to conclude that participants with poor well-being had slightly better synthesis of SusAF results compared to participants with good well-being. Particularly, the participants with poor well-being who had better synthesis were the students from LaSalle university, and this might be influenced by the data collection biases in this research study.

Addressing related works: Unfortunately, no relevant studies were found to make a comparison of answers to this research question. While Zollo, Maurizio, et al. [4] mentions sustainability mindset, it only compares between an activity for well-being and cognitive training practice. This has been addressed in the discussion for Sub RQ4 below.

5.1.4 Discussion Sub RQ4: Comparison of consideration for sustainability effects of software products and services among groups of participants based on their well-being practices.

To address this sub-research question, participants were grouped separately based on well-being activities, breathing practices or meditation, and gymming done by them. And for each case, comparison of SusAF metrics were done using the right-tailed Wilcoxon test. No significant difference was found in all metrics for groups based on well-being activities done by participants, and groups based on gymming. For the groups based breathing practices or meditation, the values were found to be significantly higher for one metric of broadness (number of negative effects) and one metric of synthesis (number of mitigating actions) favoring the group consisting of participants doing breathing exercises or meditation. For all other metrics, no significant difference was found between the groups. As a result, quanti-

tatively, no conclusion could be made about which groups have better SusAF analysis. To gain further insights on the results, qualitative analysis was carried out.

For participants who did and did not do well-being activities, no evidence was found to support if participants from either of the groups had better broadness, depth, timescale and synthesis analysis. Participants who did not do breathing exercises or meditation were found to have slightly better depth analysis, and better synthesis analysis of supporting and mitigating actions, compared to the participants who did breathing exercises. However, for broadness and timescale, enough evidence could not be found to make a conclusion. Likewise for gymming, participants who did gymming were found to have better synthesis analysis, however, for broadness, depth, and timescale, conclusive supporting evidence could not be found.

The inconclusiveness for the broadness and depth analysis is similar as mentioned in the discussion of Sub RQ3 where the effects listed were almost same in some themes, and for majority of themes they had similar level of broadness or depth, although identified by participants belonging to different groups. However, the participants who did not do breathing exercises or meditation were found to have listed effects with more detail for similar effects identified by participants who did 'breathing exercise or meditation', as such providing conclusive evidence to say participants who did not do 'breathing exercise or meditation' had a bit better depth analysis. Similarly, for the timescale analysis, most of the structural effects had basic richness, and the effects with moderate richness were comparably not very different in terms of explanation, as such no conclusive evidence was found.

Interestingly, some of the participants who did not do 'breathing exercises or meditation' and gymming had conveyed actions for opportunities and threats in a better and detailed way than those who did 'breathing exercises or meditation' and gymming respectively. However, as in discussion about Sub RQ3, these participants who did not do 'breathing exercises or meditation' and gymming were from LaSalle university, and are prone to be influenced by the data collection bias in this research study.

Addressing related works: Zollo, Maurizio, et al. [4] mentioned that meditative practices can help individuals to consider long-term consequences of their decisions and actions more effectively. In this thesis, consideration of long-term consequences were indicated by richness in the structural effects identified by participants; however this consideration was related to IT product (Chat-GPT). But enough evidence could not be found to claim that participants who did breathing practices or meditation had better synthesis analysis compared to those who did not. Hence, no claims or comparison could be made with respect to the studies by Zollo, Maurizio, et al.

5.2 Threats to Validity

This section aims to identify and discuss various threats that could impact the external, construct, and conclusion validity of this research [57].

External Validity This study was carried out among IT students to assess relationship between their well-being and sustainability mindset. The results are limited only among the IT students and can not be generalized, mostly because the sample size was small, and participants were only from two universities - LUT and La Salle. Majority of the participants were the Software Engineers for Green Deal students, who already have been taught about sustainability in a certain depth, indicating a biased sample of participants. However, the participants were from diverse education levels and different universities, which helps to mitigate this threat to some extent. To mitigate this threat in future works, diverse participants with and without in-depth knowledge on sustainability should be considered.

Construct Validity A threat to construct validity is observed from the fact that, although SusAF helps us to identify potential sustainability effects, there is no standard methods to assess SusAF results (quantitatively or qualitatively), or to compare the results among different participants to conclude who had a better consideration of sustainability for any given product or service. In an attempt to mitigate this threat, various factors for SusAF were defined with various quantitative and qualitative metrics in each factor, and those factors were analyzed to make comparisons on the SusAF results. Similarly, the method of data collection for SusAF results from the participants of LUT university is different from that of La Salle university. For LUT, SusAF results were collected through a workshop of 110 minutes whereas for LaSalle, answers were submitted by the students as a part of their online assignments. To mitigate this threat, students were suggested to consider the same time of workshop to complete the different parts of the SusAF. In future, data should be collected through the same methods to mitigate this threat completely. Also, a possible bias can also be caused by the teacher and teaching materials used to teach about the SusAF to the participating students. To mitigate this in future work or replication, the same materials could be used to teach students, following the same approach of teaching.

Along with this, the survey used for data collection consisted of various likert scales, and some open ended questions. There is a risk of participants selecting options randomly for the likert scale questions without carefully considering the options, and for open ended questions, they may have provided short or no answers (for the optional ones). As such this might result with answers that are not accurate and impact the construct validity of this study. To mitigate this threat, the participants were given clear information on the objective of the thesis and were requested to be honest with their answers. Also, they were informed that their identities would be kept anonymous during analysis of data.

Conclusion Validity A threat for the conclusion validity is the total number of participants being 30, which is a small sample size to be able to identify any significant correlation and conclusion. Also, the number of participants in good WHO-5 well-being groups was significantly less compared to the number of poor WHO-5 well-being groups, indicating that the group comparison may not be fair, and may not accurately represent the general scenario. While the well-being of the participants is not in the control of the researcher, in future, this threat can be mitigated by considering larger sample size, and making comparison between equivalent (comparable) group sizes. Also, some research bias may be observed during the analysis of results, as there is no standard way to analyze the SusAF results. To qualitatively assess SusAF results, the effects identified into different themes, various levels (basic, moderate, high) were defined for factors (Broadness, Depth, Timescale) of SusAF analysis, and order of effects were checked if they were correctly identified. This categorization depends on how the researcher interprets the effects and is prone to bias due to limited individual perspective. While peer review was done with a classmate to check the order of effects, the researcher was not able to do peer review for other categorizations including theme identification, and levels for factors. In future, this can be tackled by doing extensive peer reviews and gaining a diversified perspective on the analysis.

5.3 Future works

This research is one of the earliest studies to address 'well-being' and 'sustainability mindset' in the domain of Information Technology. In general, existing research are limited and mainly focus on mindfulness aspect of well-being and environmental aspect of sustainability, and there was no research available for these concepts in the domain of IT. This absence of research highlights the need for further exploration about well-being and sustainability, in general as well as in the field of IT. Further explorations in the field of IT could be done among students (as done in this research) as well as working professionals. As this research study had only 30 participants, one of the future work could be replicating this study with a larger sample size of population and see if conclusive results can be obtained. Additionally, this research uses limited instruments to assess well-being (WHO-5, PWB, SWLS) and sustainability mindset (belief, attitude, intention, and SusAF results). Exploring different instruments and theoretical frameworks or methodologies might provide different and deeper insights on the relationship between well-being and sustainability concepts among various field of studies, including IT. Also, research to developing a new framework to assess well-being and sustainability mindset could be another possible future work. Overall, a clear gap exists in the research which address well-being and sustainability together, and clearly there are many possibilities for future works.

6 CONCLUSION

This thesis research explores the relationship between two broader concepts: 'well-being' and 'sustainability mindset' among IT students, and serves as one of the earliest studies to address these two concepts together in the field of IT. Well-being of participants is given by the well-being score measured through standard instruments (WHO-5, PWB, and SWLS), where are the sustainability mindset is explored by assessing their belief, attitude and intention towards sustainability, and their ability to consider sustainability effects of IT products and services which was obtained from SusAF analysis of Chat-GPT. Also, comparison of these aspects of sustainability was done among various groups of participants based on their well-being score, and well-being activities done by them.

No statistical significant correlation was observed between well-being scores and belief, attitude and intention towards sustainability. Additionally, significant differences were not found between groups of participants based on well-being as well as groups based on well-being activities done (also 'breathing exercises or meditation' and gymming) in terms of belief, attitude and intention towards sustainability. However, all the participants were found to be familiar with sustainability and its importance through various sources, which was evident through their scores for various statements of belief, attitude and intention towards sustainability.

The quantitative analysis of SusAF results presented statistical differences for some metrics of SusAF factors, the qualitative analysis showed evidence for some factors favoring participants with poor well-being, who did not do 'breathing exercises or meditation' as well as who did not do gymming. However, overall there was no conclusive evidence to strongly support if participants with good or poor well-being as well as participants belonging to groups based on well-being activities had better consideration of sustainability effects.

To conclude, the findings of this study has mostly resulted in an inconclusive relationship among 'well-being' and various measures to assess 'sustainability mindset' among IT students. However, this topic of research being relatively new, the research highlights the need for further investigation to reach some conclusion. As such, future studies should be carried out to explore this topic in a comprehensive way to gain valuable insights and contribute to this topic of research in the field of Information Technology.

REFERENCES

[1] A. M. Tjoa and S. Tjoa, "The role of ict to achieve the un sustainable development goals (sdg)," in *ICT for Promoting Human Development and Protecting the Environment: 6th IFIP World Information Technology Forum, WITFOR 2016, San José, Costa Rica, September 12-14, 2016, Proceedings 6*, Springer, 2016, pp. 3–13.

[2] *Computer science now the fastest growing degree subject, new data reveals*, Aug. 2022. [Online]. Available: `https://www.bcs.org/articles-opinion-and-research/computer-science-now-the-fastest-growing-degree-subject-new-data-reveals/`.

[3] B. Bernárdez Jiménez, A. Durán Toro, J. A. Parejo Maestre, N. Juristo, and A. Ruiz Cortés, "Effects of mindfulness on conceptual modeling performance: A series of experiments," *IEEE Transactions on Software Engineering, 48 (2), 432-452.*, 2022.

[4] M. Zollo, A. Dodich, V. Vastola, *et al.*, "Developing sustainability mindsets: A rct on the efficacy of cognitive training and meditation," in *Academy of Management Proceedings*, Academy of Management Briarcliff Manor, NY 10510, vol. 2018, 2018, p. 15 848.

[5] U. B. Thiermann and W. R. Sheate, "How does mindfulness affect pro-environmental behaviors? a qualitative analysis of the mechanisms of change in a sample of active practitioners," *Mindfulness*, vol. 13, no. 12, pp. 2997–3016, 2022.

[6] T. Ericson, B. G. Kjønstad, and A. Barstad, "Mindfulness and sustainability," *Ecological Economics*, vol. 104, pp. 73–79, 2014.

[7] C. Wamsler and E. Brink, "Mindsets for sustainability: Exploring the link between mindfulness and sustainable climate adaptation," *Ecological Economics*, vol. 151, pp. 55–61, 2018.

[8] L. Ramstetter, S. Rupprecht, L. Mundaca, *et al.*, "Fostering collective climate action and leadership: Insights from a pilot experiment involving mindfulness and compassion," *iScience*, vol. 26, no. 3, p. 106 191, 2023.

[9] C. Krekel and A. Prati, "Linking subjective wellbeing and pro-environmental behaviour: A multidimensional approach," *Linking Sustainability and Happiness: Theoretical and Applied Perspectives*, pp. 175–201, 2022.

[10] J. Jacob, E. Jovic, and M. B. Brinkerhoff, "Personal and planetary well-being: Mindfulness meditation, pro-environmental behavior and personal quality of life in a survey from the social justice and ecological sustainability movement," *Social Indicators Research*, vol. 93, pp. 275–294, 2009.

[11] S. Imperatives, "Report of the world commission on environment and development: Our common future," *Accessed Feb*, vol. 10, pp. 1–300, 1987.

[12] W. M. Adams, "The future of sustainability: Re-thinking environment and development in the twenty-first century," 2006.

[13] T. Hodge, "Toward a conceptual framework for assessing progress toward sustainability," *Social indicators research*, vol. 40, no. 1-2, pp. 5–98, 1997.

[14] *Transforming our world: The 2030 agenda for sustainable development*, 2015. [Online]. Available: `https://sdgs.un.org/2030agenda`.

[15] C. Calero, M. Á. Moraga, and M. Piattini, "Introduction to software sustainability," *Software Sustainability*, pp. 1–15, 2021.

[16] *Constitution of the world health organization*. [Online]. Available: `https://www.who.int/about/governance/constitution`.

[17] S. L. McGregor and E. B. Goldsmith, "Expanding our understanding of quality of life, standard of living, and well-being," *Journal of Family and Consumer Sciences*, vol. 90, no. 2, p. 2, 1998.

[18] D. J. O'Hara and E. F. O'Hara, "Hope and well-being in sustainable development," 2020.

[19] Y. Amichai-Hamburger, *Technology and psychological well-being*. Cambridge University Press, 2009.

[20] B. Penzenstadler, R. Torkar, and C. Martinez Montes, "Take a deep breath: Benefits of neuroplasticity practices for software developers and computer workers in a family of experiments," *Empirical Software Engineering*, vol. 27, no. 4, p. 98, 2022.

[21] F. J. Penedo and J. R. Dahn, "Exercise and well-being: A review of mental and physical health benefits associated with physical activity," *Current opinion in psychiatry*, vol. 18, no. 2, pp. 189–193, 2005.

[22] E. Warnecke, S. Quinn, K. Ogden, N. Towle, and M. R. Nelson, "A randomised controlled trial of the effects of mindfulness practice on medical student stress levels," *Medical education*, vol. 45, no. 4, pp. 381–388, 2011.

[23] M. D. Bamber and E. Morpeth, "Effects of mindfulness meditation on college student anxiety: A meta-analysis," *Mindfulness*, vol. 10, no. 2, pp. 203–214, 2019.

[24] V. Lemay, J. Hoolahan, and A. Buchanan, "Impact of a yoga and meditation intervention on students' stress and anxiety levels," *American journal of pharmaceutical education*, vol. 83, no. 5, 2019.

[25] *Global diffusion of ehealth: Making universal health coverage achievable: Report of the third global survey on ehealth*. [Online]. Available: `https://www.who.int/publications/i/item/9789241511780`.

[26] C. Burr, M. Taddeo, and L. Floridi, "The ethics of digital well-being: A thematic review," *Science and engineering ethics*, vol. 26, no. 4, pp. 2313–2343, 2020.

[27] B. Tanveer, "Sustainable software engineering-have we neglected the software engineer's perspective?" In *2021 36th IEEE/ACM International Conference on Automated Software Engineering Workshops (ASEW)*, IEEE, 2021, pp. 267–270.

[28] I. M. Hosking and K. Livingstone, "Meta-usability: Understanding the relationship between information technology and well-being," in *Design, User Experience, and Usability: Design Thinking and Practice in Contemporary and Emerging Technologies: 11th International Conference, DUXU 2022, Held as Part of the 24th HCI International Conference, HCII 2022, Virtual Event, June 26–July 1, 2022, Proceedings, Part III*, Springer, 2022, pp. 14–32.

[29] D. Graziotin, F. Fagerholm, X. Wang, and P. Abrahamsson, "What happens when software developers are (un) happy," *Journal of Systems and Software*, vol. 140, pp. 32–47, 2018.

[30] M. M. Uddin, A. Farjana, M. Mamun, and M. A. Mamun, "Mental health analysis in tech workplace," in *Proceedings of the 7th North American International Conference on Industrial Engineering and Operations Management*, IEOM Society International, 2022.

[31] T. Helne and T. Hirvilammi, "Wellbeing and sustainability: A relational approach," *Sustainable Development*, vol. 23, no. 3, pp. 167–175, 2015.

[32] A. Bandarage, *Sustainability and well-being: the middle path to environment, society and the economy*. Springer, 2013.

[33] I. Rimanoczy, *The sustainability mindset principles: A guide to developing a mindset for a better world*. Routledge, 2020.

[34] B. Barrett, M. Grabow, C. Middlecamp, *et al.*, "Mindful climate action: Health and environmental co-benefits from mindfulness-based behavioral training," *Sustainability*, vol. 8, no. 10, p. 1040, 2016.

[35] A. Wiek, L. Withycombe, and C. L. Redman, "Key competencies in sustainability: A reference framework for academic program development," *Sustainability science*, vol. 6, pp. 203–218, 2011.

[36] E. Berejnoi, D. Messer, and S. Cloutier, "Cultivating spiritual well-being for sustainability: A pilot study," *Sustainability*, vol. 12, no. 24, p. 10 342, 2020.

[37] H. L. Burns, "Transformative sustainability pedagogy: Learning from ecological systems and indigenous wisdom," *Journal of Transformative Education*, vol. 13, no. 3, pp. 259–276, 2015.

[38] C. B. Onete, S. Budz, and I. Teodorescu, "Connections between spirituality and sustainability," in *Building Engagement for Sustainable Development: Challenges of Sustainable Economy in Times of Accelerated Change*, Springer, 2019, pp. 1–22.

[39] L. Goralnik and S. Marcus, "Resilient learners, learning resilience: Contemplative practice in the sustainability classroom," *New Directions for Teaching and Learning*, vol. 2020, no. 161, pp. 83–99, 2020.

[40] R. Ulluwishewa, "Spirituality, sustainability and happiness: A quantum-neuroscientific perspective," *Spirituality and Sustainability: New Horizons and Exemplary Approaches*, pp. 155–168, 2016.

[41] L. Duboc, B. Penzenstadler, J. Porras, *et al.*, *Requirements Engineering*, vol. 25, pp. 469–492, 2020.

[42] C. Becker, R. Chitchyan, L. Duboc, *et al.*, "The karlskrona manifesto for sustainability design," *arXiv preprint arXiv:1410.6968*, 2014.

[43] U. B. Thiermann and W. R. Sheate, "The way forward in mindfulness and sustainability: A critical review and research agenda," *Journal of Cognitive Enhancement*, vol. 5, pp. 118–139, 2021.

[44] K. W. Brown and T. Kasser, "Are psychological and ecological well-being compatible? the role of values, mindfulness, and lifestyle," *Social indicators research*, pp. 349–368, 2005.

[45] M. Giltrow, "Investigating the relationship of wellbeing with sustainable values, attitudes and behaviour," *Transformative Approaches to Sustainable Development at Universities: Working Across Disciplines*, pp. 91–102, 2015.

[46] C. Wamsler, "Mind the gap: The role of mindfulness in adapting to increasing risk and climate change," *Sustainability Science*, vol. 13, pp. 1121–1135, 2018.

[47] H.-H. Wang, Z.-R. Hong, H.-s. Lin, and C.-Y. Tsai, "The relationships among adult sustainability attitudes, psychological well-being, nature relatedness, and interest in scientific issues," *Current Psychology*, pp. 1–12, 2020.

[48] M. Hunecke and N. Richter, "Mindfulness, construction of meaning, and sustainable food consumption," *Mindfulness*, vol. 10, no. 3, pp. 446–458, 2019.

[49] S. M. Geiger, D. Fischer, U. Schrader, and P. Grossman, "Meditating for the planet: Effects of a mindfulness-based intervention on sustainable consumption behaviors," *Environment and Behavior*, vol. 52, no. 9, pp. 1012–1042, 2020.

[50] A. Sajjad and W. Shahbaz, "Mindfulness and social sustainability: An integrative review," *Social Indicators Research*, vol. 150, no. 1, pp. 73–94, 2020.

[51] W. H. Organization, *Who-5 questionnaires*. [Online]. Available: `https://www.psykiatri-regionh.dk/who-5/Documents/WHO-5%20questionaire%20-%20English.pdf`.

[52] C. W. Topp, S. D. Østergaard, S. Søndergaard, and P. Bech, "The who-5 well-being index: A systematic review of the literature," *Psychotherapy and psychosomatics*, vol. 84, no. 3, pp. 167–176, 2015.

[53] E. Diener, D. Wirtz, R. Biswas-Diener, *et al.*, "New measures of well-being," *Assessing well-being: The collected works of Ed Diener*, pp. 247–266, 2009.

[54] E. Diener, R. A. Emmons, R. J. Larsen, and S. Griffin, "The satisfaction with life scale," *Journal of personality assessment*, vol. 49, no. 1, pp. 71–75, 1985.

[55] W. Pavot, E. Diener, C. R. Colvin, and E. Sandvik, "Further validation of the satisfaction with life scale: Evidence for the cross-method convergence of well-being measures," *Journal of personality assessment*, vol. 57, no. 1, pp. 149–161, 1991.

[56] K. H. D. Tang, "Correlation between sustainability education and engineering students' attitudes towards sustainability," *International Journal of Sustainability in Higher Education*, vol. 19, no. 3, pp. 459–472, 2018.

[57] D. T. Campbell and T. D. Cook, "Quasi-experimentation," *Chicago, IL: Rand McNally*, 1979.

[58] D. F. Carr. [Online]. Available: `https://www.similarweb.com/blog/insights/ai-news/chatgpt-1-billion/`.

A APPENDIX: Well-being instruments

A.1 The 5-item World Health Organization Well-Being Index (WHO-5)

The five items of WHO-5 well-being index is shown in Table 39, in which the respondents rate about how they have felt over the last two weeks from the scale of 0 - 5 where,
0 = None of the time, 1 = Some of the time, 2 = Less than half the time, 3 = More than half the time, 4 = Most of the time, and 5 = All of the time.

Table 39: WHO-5 Questionnaires Items

Item	**Statement: Over the last two weeks,...**
who-1	I have felt cheerful and in good spirits.
who-2	I have felt calm and relaxed.
who-3	I have felt active and vigorous.
who-4	I woke up feeling fresh and rested.
who-5	My daily life has been filled with things that interest me.

Result Interpretation: The total score is obtained by adding the score of individual items. As such the score can range from 0 - 25, where *the score below 13 indicates poor well-being*, and *the score equal to or higher than 13 indicates good well-being*. If the score is below 13 or the score on any item is 0 or 1, then it is recommended to test for depression under ICD-10.

A.2 Diener et al's scale of Psychological Well-Being (PWB)

The eight items of PWB is shown in Table 40, in which the respondents rate from 1 - 7 where, *1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neutral (neither agree nor disagree), 5 = Slightly Agree, 6 = Agree, 7 = Strongly Agree.*

Result Interpretation: The total score can range from 8 (Strong disagreement with all items) to 56 (Strong agreement with all items). High score imply that the respondents view themselves in very positive terms in diverse areas of functioning.

For this study, the scores were classified into seven categories as shown below:
49 - 56*: Extremely Satisfied;* ***41-48****: Satisfied;* ***33-40****: Slightly Satisfied;* ***32****: Neutral*
24-31*: Slightly Dissatisfied;* ***16-23****: Dissatisfied;* ***8-15****: Extremely Dissatisfied*

Table 40: PWB Items

Item	Statement
pwb-1	I lead a purposeful and meaningful life.
pwb-2	My social relationships are supportive and rewarding.
pwb-3	I am engaged and interested in my daily activities.
pwb-4	I actively contribute to the happiness and well-being of others.
pwb-5	I am competent and capable in the activities that are important to me.
pwb-6	I am a good person and live a good life.
pwb-7	I am optimistic about my future.
pwb-8	People respect me.

A.3 Satisfaction with Life Scale (SWLS)

The five items of SWLS is shown in Table 41, in which the respondents from the scale of 1 - 7 where, *1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neutral (neither agree nor disagree), 5 = Slightly Agree, 6 = Agree, 7 = Strongly Agree.*

Table 41: SWLS Items

Item	Statement
swls-1	I In most ways my life is close to my ideal.
swls-2	The conditions of my life are excellent.
swls-3	I am satisfied with my life.
swls-4	So far I have gotten the important things I want in life.
swls-5	If I could live my life over, I would change almost nothing.

Result Interpretation Score can range from 5 (Strong disagreements with all items) to 35 (Strong agreements with all items). Higher score represents higher life satisfaction. The scores can be classified into six well-being categories as follows:
30 - 35*: Extremely Satisfied;* ***25-29****: Satisfied;* ***20-24****: Slightly Satisfied;*
15-19*: Slightly Dissatisfied;* ***10-14****: Dissatisfied;* ***5-9****: Extremely Dissatisfied*

B APPENDIX: Statements for Belief, Attitude, Intention towards Sustainability

Table 42: Belief, Attitude and Intention towards Sustainability

Item	Statement
Belief statements	
B1	I feel more morally obliged to do something about environmental problems.
B1.5	I feel more morally obliged to do something about social problems.
B1.5	I think I should take more responsibility for sustainable development.
B4	I believe that humans have the right to subdue and control nature.
B5	I believe that humans should adapt to nature rather than modify it to suit them.
B6	I think it is important to control human population to ensure social sustainability.
Attitude statements	
A1	I am more aware of current environmental, social, economic and cultural issues.
A2	I can analyse issues related to sustainable development more holistically.
A3	I am more concerned about environmental pollutions.
A4	I am more willing to safeguard sustainable development.
A5	I make an effort to use green products and services whenever possible.
A6	I refuse the use of packaging.
A7	I set aside garbage for reuse, recycling or safe disposal.
A8	I reduce the use of air-conditioning, lighting and domestic electrical appliances
A9	I consciously make a change in my lifestyle to reduce my carbon footprint
A10	I consciously reduce the amount of wastes generated from my daily activities
A11	I make an effort to use energy and resources more efficiently
A12	I reduce water consumption
A13	I am willing to pay more for energy-efficient products
Intention statements	
I1	I prefer to work for an environmentally responsible employer in the future
I2	I prefer to work for a socially responsible employer in the future
I3	I intend to change/continue to change my lifestyle for better sustainability
I4	I will promote the concept of sustainable development to my family and friends
I5	I will participate in campaigns/causes that promote sustainable development
I6	I will apply the concept of triple bottom line (Economic, Social, Environmental impacts) more in making decisions

C APPENDIX: SURVEY FORM

Thesis study on Well-Being and sustainability mindset of Students

Researchers:
Shrawan Bishowkarma (shrawan.bishowkarma@student.lut.fi) | Erasmus Mundus Scholar in Software Engineers for Green Deal program | LUT University, Finland
Dr. Birgit Penzenstadler (birgitp@chalmers.se) | Associate Professor, Chalmers University of Technology
Dr. Leticia Duboc (l.duboc@salle.url.edu) | Lecturer and Researcher at La Salle ´´ Ramon Llull University, Spain

Purpose of the research study: The purpose of this thesis-research study is to examine the well-being of students from IT, computer science, software engineering and similar fields, and their mindset about sustainability. To do this, you are asked to participate voluntarily and contribute to the research study filling up this survey form.

Time taken to fill the survey: It will take about 10 - 12 minutes to fill and submit the survey.

Types of Data : We use reliable standard survey instruments, which have been developed under rigorous quality, and are derived from validated research. These include closed-ended multiple choice questions where you chose a rating, and open-ended questions where we ask for examples of your experiences. Also, some of the questions are optional, whereas some of them are compulsory.

Potential Risks and Discomforts : We had to ask for your email address in the survey so that we could send you the survey you filled, share research report, and other surveys (if additionally needed for the research purpose). To maintain your anonymity, you can create a 'special nickname' for yourself in this survey form, and the nickname will be used to identify the response, link your survey data to SusAF workshop data and analyze them.

The risks of participating in this study are minimal. However, there is a small risk of inadvertent disclosure. In addition, your identity and the study findings may be disclosed through legal action - when, for example, non-disclosure would constitute contempt of court. However, as far as possible, we will ensure that any such disclosure is very unlikely.

Potential Benefits for participants: By filling up a series of questions in this survey, you can get a reflection on your personal well-being, and your thinking of sustainability. This reflection might be useful for you to make changes in your daily lifestyle (if needed) for your own well-being and also contributing to a more sustainable world.

Upon request, we can also provide the interested participants to examine and study our research results.

Payment for participation: You will not be paid for participating in this study.

Participation and withdrawal: Your participation for this research is completely voluntary, and you may withdraw at any time without consequences of any kind.

Identification of investigators: If you have any queries or concerns regarding this research, please feel free to contact Shrawan Bishowkarma (shrawan.bishowkarma@student.lut.fi) or Dr. Birgit Penzenstadler (birgitp@chalmers.se) or Dr. Leticia Duboc (l.duboc@salle.url.edu)

Signature of research subject: I understand the procedures and conditions of my participation described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form. By clicking next, I agree to the procedures and conditions.

We follow standard ethics procedures at the University of Chalmers, Sweden.

To take part in this study, please provide your email and click next. You are agreeing to voluntarily participate in the study and let us use the data we collect for research. You have rights to withdraw this study at any time.

Email*

Demographics

The demographics will be used during data analysis and statistics.

A special Nickname (which is as unique as possible, and easy for you to remember) *
The nickname will be used to link your entries, and will be used to analyze the data by maintaining your anonymity. Please put this nickname in the sheet you fill during the workshop.

What is your age (in years) ? *

What is your gender identity?

Which university are you attending? *

What is your faculty of study? *

What is your current educational level? *

- Bachelors degree - Year 1
- Bachelors degree - Year 2
- Bachelors degree - Year 3
- Bachelors degree - Year 4
- Masters degree - Year 1
- Masters degree - Year 2
- PhD - Year 1
- PhD - Year 2
- PhD - Year 3
- PhD - Year 4
- Other:

The WHO-5 Well Being Index

Below are five statements that you may agree or disagree with.

Using the 0 - 5 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item.

Please be open and honest in your response.

1) Over the last two weeks, I have felt **cheerful** and in **good spirits**.*
    - 0 - None of the time
    - 1 - Some of the time
    - 2 - Less than half the time
    - 3 - More than half the time
    - 4 - Most of the time
    - 5 - All of the time
2) Over the last two weeks, I have felt **calm** and **relaxed**.*
3) Over the last two weeks, I have felt **active** and **vigorous**.*
4) Over the last two weeks, I woke up feeling **fresh** and **rested**.*
5) Over the last two weeks, My daily life has been filled with things that interest me.*

The Psychological well-being (PWB) (Diener et al. 2009)

Below are five statements that you may agree or disagree with.

Using the 0 - 5 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item.

Please be open and honest in your response.

1) I lead a purposeful and meaningful life.*
    - 1 - Strongly Disagree
    - 2 - Disagree
    - 3 - Slightly Disagree
    - 4 - Neutral (neither agree nor disagree)
    - 5 - Slightly Agree
    - 6 - Agree
    - 7 - Strongly Agree
2) My social relationships are supportive and rewarding.*
3) I am engaged and interested in my daily activities.*
4) I actively contribute to the happiness and well-being of others.*
5) I am competent and capable in the activities that are important to me.*

6) I am a good person and live a good life.*
7) I am optimistic about my future.*
8) People respect me.*

SWLS (5 items on life satisfaction)

Below are five statements that you may agree or disagree with.

Using the 1 - 7 scale below, indicate your agreement with each item by placing the appropriate number on the line preceding that item.

Please be open and honest in your response.

1) In most ways my life is close to my ideal.*
    - 1 - Strongly Disagree
    - 2 - Disagree
    - 3 - Slightly Disagree
    - 4 - Neutral (neither agree nor disagree)
    - 5 - Slightly Agree
    - 6 - Agree
    - 7 - Strongly Agree
2) The conditions of my life are excellent.*
3) I am satisfied with my life.*
4) So far I have gotten the important things I want in life.*
5) If I could live my life over, I would change almost nothing.*

Your Well-being Practices/Activities

Do you do any practices or activities for your well being?

- Yes
- No

Your Well-being Practices/Activities

This section consists of questions related to activities you do for your well-being, and how often you do them.

What **activities** do you do for your **physical well being**? Please separate your activities using comma (E.g. Gym, walk, running, sports etc.)

(If you answered above question) How many hours a week do you usually engage in the activities you mentioned above?

- Less than 1 hour per week

- 1 to 4 hours per week
- 4 to 8 hours per week
- 8 to 12 hours per week
- 12+ hours per week

What **activities** do you do for your **emotional and mental well being**? Please separate your activities using comma (Mindfulness Meditation, breathing exercise etc.)

(If you answered above question) How many hours a week do you usually engage in the activities you mentioned above?

Any other activities that you do for your well being? Please separate your activities using comma (Engage in hobbies like cook food, read etc.)

(If you answered above question) How many hours a week do you usually engage in the activities you mentioned above?

Familiarity with Sustainability

This sections is aimed to analyze the familiarity of participants with sustainability.

What is your understanding of the term "sustainability"?*

On a scale of **1-5**, please indicate the extent to which the following sources have contributed to your familiarity with sustainability. Please rate each option where 1 indicates "not at all" and 5 indicates "to a very great extent".

1) I read about sustainability from news, websites, and social media *
    - 1 - Not at all
    - 2 - To a small extent
    - 3 - To some extent
    - 4 - To a great extent
    - 5 - To a very great extent
2) I discuss about sustainability with my friends, families or colleagues *
3) I have read books (at least one) about sustainability *
4) I learn through active engagement in community activities or political action *
5) I study about sustainability in academic courses *

What do you do for sustainability in your daily life? Please list some concrete examples.

Belief, Attitude and Intention towards Sustainability

Below are statements related to your belief, attitude, and intention towards sustainability, which you may agree or disagree.

Using the 1 (Strongly disagree) – 5 (Strongly agree) scale below, indicate your agreement with each item by indicating that response for each statement.

Please be open and honest in your response.

This section contains 6 statements related to your belief towards sustainability

1) I feel more morally obliged to do something about environmental problems *
    - 1 - Strongly disagree
    - 2 - Disagree
    - 3 - Neutral
    - 4 - Agree
    - 5 - Strongly Agree
2) I feel more morally obliged to do something about social problems *
3) I think I should take more responsibility for sustainable development *
4) I believe that humans have the right to subdue and control nature *
5) I believe that humans should adapt to nature rather than modify it to suit them *
6) I think it is important to control human population to ensure social sustainability *

This section contains 13 statements related to your attitude towards sustainability

1) I am more aware of current environmental, social, economic and cultural issues *
    - 1 - Strongly disagree
    - 2 - Disagree
    - 3 - Neutral
    - 4 - Agree
    - 5 - Strongly Agree
2) I can analyse issues related to sustainable development more holistically *
3) I am more concerned about environmental pollutions *
4) I am more willing to safeguard sustainable development *
5) I make an effort to use green products and services whenever possible *
6) I refuse the use of packaging *
7) I set aside garbage for reuse, recycling or safe disposal *
8) I reduce the use of air-conditioning, lighting and domestic electrical appliances *
9) I consciously make a change in my lifestyle to reduce my carbon footprint *
10) I consciously reduce the amount of wastes generated from my daily activities *
11) I make an effort to use energy and resources more efficiently *
12) I reduce water consumption *
13) I am willing to pay more for energy-efficient products *

This section contains 6 statements related to your intention towards sustainability

1) I prefer to work for an environmentally responsible employer in the future *
    - 1 - Strongly disagree
    - 2 - Disagree
    - 3 - Neutral
    - 4 - Agree
    - 5 - Strongly Agree
2) I prefer to work for a socially responsible employer in the future *
3) I intend to change/continue to change my lifestyle for better sustainability *
4) I will promote the concept of sustainable development to my family and friends *
5) I will participate in campaigns/causes that promote sustainable development *
6) I will apply the concept of triple bottom line more in making decisions *

Report preferences

Would you like to receive a research report after the study is completed?

- Yes
- No

D Participant's Understanding of the term 'Sustainability'

The understanding of the term 'Sustainability" among participants is presented separately for participants with good and poor WHO-5 based well-being groups. They are presented in Table 43 and 44.

One participant belonging to good well-being group had stated "Medium Knowledge", which was discarded as this explained more about how much understanding the participant has about sustainability rather than explaining the understanding of the term 'sustainability'.

Table 43: Participants' understanding of the term "Sustainability" (n = 8, poor well-being)

Sustainability Understanding
Protect the need of current generation without compromise the future
Longevity and preservance
Sustainability refers to the concept of meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.
In simple terms, sustainability is the ability to sustain something for a long while
Don't harm the Earth and practice sustainable activities that tackle all 5 dimensions of sustainability.
Things that are contribute to the greater good. Not as individuals but for humanity or even life.
Living without harming the environment
Been good for a long time

Table 44: Participants' understanding of the term "Sustainability" (n = 21, good well-being)

Sustainability Understanding
the ability to maintain or support something over the long term
The mindful uses of resources
A net zero footprint life - taking and giving back into the planetary resources are in balance.
Optimizing the usage of resources in a way to maximize usage and try to save those resources for future generations
Consumption of resources for fulfilling needs without compromising needs of future generations
The ability to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. It involves balancing economic, environmental, and social factors to ensure long-term well-being and resource conservation.
Being able to use resources in a way that you don't run out of them
Well being of life in all dimensions sustained for the future years
The ability to exist and grow for a longer course of time without having or a minimum impact on environment, society, individual, and economic condition.
Making the actions of today while putting in mind the ramifications of it on multiple dimensions in the short and long term.
Being in balance with life, bringing no harm to surroundings, and being helpful as much as possible
Sustainability is for long term and beneficial for future without using lot of resources.
Brundtland report definition + the use of sustainability dimensions depending of the scope of the usecase
The concept of making sustainable choices in every aspect of life
To not negatively affect environment or surroundings (people, places) by my actions and live in a peaceful way while encouraging the positive practices of sustainability
To preserve/save and consume carefully the resources you have to last it for future
It is a very broad concept, but overall it is all about entertaining life while keeping other things like the environment, the current and future generation in mind.
Well, in short its preserving the resources and careful use
To sustain and use resources according to needs without affecting future generations
It is a realm of thinking that deals with the balance of systems to ensure their continuity.
Raise awareness and take the necessary actions to ensure that our daily activities do not impact the environment.

E APPENDIX: SusAF Materials

This section includes the questionnaires used for data collection through SusAF workshop and assignments.

E.1 SusAF Questions

1. **Dimensions: Social**

   Trust means having a firm belief in the reliability, truth, or ability of someone or something.

   - How can the product or service change the trust between people and other people, the business, or other institutions?

   Equity means the quality of being fair and impartial.

   - How can the system make people to be treated differently from each other? (think data analytics or decision support)

2. **Dimensions: Individual**

   Health means the state of a person‘s mental or physical condition.

   - How can the product or service improve or worsen a person’s physical, mental, and/or emotional health?
   - (For example, can it make a person feel anything good or bad - e.g. (under)valued, (dis) respected, (in)dependent, or coerced?)

   Self-awareness and Free will means the capacity of an individual to act or make decisions on their own.

   - How can the product or service empower (or prevent) a person from taking an action / decision when necessary?
   - Can those affected by the product or service understand its implications, express concerns or be represented by someone?

3. **Dimensions: Environment**

   Waste & pollution means effects the product or service might have on soil, atmospheric, and water pollution.

   - How can producing parts or supplies generate waste or emissions?
   - How can the use itself produce waste or emissions?
   - How can it influence how much waste or emissions are generated?
   - How can it promote (or impair) recycling?

   Energy means all energy use that results from producing and using a product or service.

   - How can the product of service affect the need for production of energy?
   - What about the use of energy? E.g. encourages less energy.
   - Does the hardware run on renewable energy? Is there a way to incentivise that?

4. **Dimensions: Economic**

   Value means the worth, or usefulness of something, principles or standards; judgement of what is important in life.

- How can the product or service create or destroy monetary value? For whom?
- Are there any other related types of business value? For whom?

Customer Relationship Management steers a company's interaction with current and potential customers to improve business relationships (e.g. retention, growth).

- How can the product or service affect the relationship between the business and its customers?
- How can it enable co-creation or co-destruction of value?
- How can it impact the financial situation of their customers & others?

5. **Dimensions: Technical**

   Security means freedom from, or resilience against, potential harm (or other unwanted coercive change) caused by external or internal attacks.

   - Which assets controlled by this system would be desirable to an attacker? E.g. financial information, people's whereabouts or preferences, etc.
   - What are the risks associated with these assets?
   - What are other likely vulnerabilities of the system?

   Scalability means the systems ability to handle growing amounts of work in a graceful manner or to be enlarged horizontally or vertically and will continue to function with comparable response times.

   - How can the system support changes in workload?
   - What can make that easier/more difficult?

E.2 Software product used for SusAF

Chat-GPT (Fastest growing app in the world) [58]

- A trained AI chatbot model developed by OpenAI
- Launched - Nov 2022
- 1 million users in 5 days
- 150 million+ unique active users in Feb 2023
- 1 Billion+ visits to chat.openai.com in Feb 2023

F APPENDIX: Themes per dimension

F.1 Social Dimension Themes

Theme	Effects count	Theme	Effects count
1) Bias Information and Concerns	17	17) Lack of transparency	2
2) Inequity and Inequality in Society	12	18) Increase Trust	2
3) Lower Trust (society)	11	19) Overtrust information	2
4) Academic Cheating and Distrust	6	20) Dependency on Technology	2
5) Promote Equity	6	21) Ethical and Emotional concerns of AI	2
6) Benefits of Answers	5	22) Human vs Machine	2
7) Unsuitable Answers	5	23) ChatGPT integration	2
8) Access to Information	5	24) Aware Society	1
9) Privacy and Security Issue	4	25) No originality and No Creativity	1
10) Reliability and Authenticity	3	26) Increased social interaction	1
11) Language Inclusivity and Trust Fostering	3	27) Hold sensitive information	1
12) Enhance Communication	3	28) Business Decision Support	1
13) Information Verification	3	29) Online education	1
14) Reduced human interaction	3	30) Society Radicalization	1
15) Accurate Info	2	31) Global Empowerment	1
16) Lack of Inclusiveness	2	32) Decreased Teachers' work value	1

F.2 Environmental Dimension Themes

Theme	Effects count	Theme	Effects count
1) Energy by Hardware and Infrastructure	13	11) Sustainable practices with resources	3
2) Energy by high usage	9	12) Increased Resource Consumption	3
3) Model Training Effects	9	13) Increased hardware production	3
4) Reduce Waste, Energy, and resources	8	14) Raw Material Extraction	2
5) E-waste and effects	7	15) Energy Production	2
6) Aware users about sustainability	7	16) Global Warming	1
7) Energy by the product	6	17) Creation of similar models	1
8) Green House and Carbon emission	6	18) Improving Algorithms	1
9) High Water Usage	4	19) Decreased Commuting	1
10) Reduced paper and benefits	4		

F.3 Individual Dimension Themes

Theme	Effects count	Theme	Effects count
1) Learning, Personal Development Support and Empowerment	17	15) Impact of Biased Information	3
2) Influence Decision Making and Actions	17	16) Independent Feeling	2
3) Improve Mental and Emotional health	10	17) Social Isolation	2
4) Negative Mental Health Impacts	10	18) Stress on being caught	1
5) Addiction and Dependency	10	19) Fear of regulations against Chat-GPT	1
6) Diminish Thinking abilities	9	20) Gradual Change in Mindset	1
7) Save Time and Effort	9	21) Accurate Information	1
8) Incorrect Answers / MisInformation and Impacts	6	22) No possibility of Concerns Expression	1
9) Accessible Health Care Advice	5	23) Trust Issue	1
10) (Personalized) Recommendations	4	24) Lack of Understanding	1
11) Information security issues	4	25) Hard Legal Redressal	1
12) Diminished self-value	4	26) Unemployment Risk	1
13) Reduced social isolation	4	27) Reduce Free will and Self Awareness	1
14) Improved task efficiency	4	28) Reduced Education Quality	1

F.4 Technical Dimension Themes

Theme	Effects count	Theme	Effects count
1) Privacy and Security Issues	28	10) Verification and authorship concerns	2
2) Services and Advancement with Chat-GPT	10	11) Easy Usability	2
3) Decreased Usability	7	12) No information breach	1
4) Analyze, optimize and automate	6	13) E-waste	1
5) Scalability Needs, Possibilities and concerns	6	14) Hardware obsolescence	1
6) Need for more resources and hardware	5	15) Code Sharing Concern	1
7) Teach/Learn platform	4	16) Analyze and predict user whereabouts	1
8) Ethical usage of ChatGPT	3	17) Excessive Dependency Risk	1
9) User input at training data	2	18) AI evolving risks	1

F.5 Economic Dimension Themes

Theme	Effects count	Theme	Effects count
1) Impact on Employment	23	16) Learning Opportunities	2
2) Improved Customer Service and Engagement	7	17) Time Saving and relief	2
3) Increase efficiency and optimization	7	18) Marketing	2
4) Cost Saving for Business	6	19) Customers decision making and finance advice	2
5) Support New Product Development	5	20) Possibility of AI revolution	2
6) Ethical Concerns	5	21) Cheaper services	2
7) Ideas generation and problem solving	5	22) Investment in OpenAI	1
8) Task / Process Automation and Redundancy	5	23) Expensive Training Cost	1
9) Data Analysis	4	24) Students' dependency on ChatGPT	1
10) Business dependency on ChatGPT	4	25) Downside of dependency	1
11) Negative Impact on Business that fail to adapt	4	26) Risk of losing customers	1
12) Value co-creation and customer engagement	3	27) Educational establishments	1
13) Better Value	3	28) Increased Usage	1
14) Create Monetary Value	3	29) Possible Economic Collapse	1
15) Destroy Monetary Value	3		