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Investigating Students' Sustainability Awareness and the Curriculum of Technology Education in Pakistan

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Received: 28 March 2019; Accepted: 3 May 2019; Published: 9 May 2019

Abstract: Various fields of manufacturing, management, and business, including technology education, software development, and information communication technology (ICT), have espoused sustainability concepts. Including sustainability concepts in technology, education can help students learn how to implement the dimensions of sustainability (economic, social, and environmental). Lack of awareness and education regarding sustainability among students can impact their competence to incorporate sustainability into technology development. Thus, the development of student competence across the curriculum of technology education for sustainability is crucial. This research aims to explore student competence development in technology education (IT, computer science, and software development) through investigating their awareness of sustainability, and to investigate how much sustainability is infused across the technology education curriculum. The case study for this research is taken from a very populous and developing country—Pakistan. First, an in-depth survey of higher education students is conducted to investigate their awareness level of sustainability. Second, qualitative document analysis is conducted, where the standard curriculum for technology education is taken and analyzed for its provision towards sustainability. A total of 159 students from various public-sector universities of Pakistan reported their awareness towards sustainability. The results show that 71% of them are unaware of the term sustainability in their respective fields, only 17% students know the basic definition of sustainability, and 12% of students have just an idea of how sustainability is related to technology education. It is also observed that the current curriculum of technology education does not sufficiently cover specific subjects or topics that can help students understand the concepts of sustainability. This study highlights the gaps in the offered curriculum for building the desired competence of students in technology education.

Keywords: sustainability; curriculum; technology education; competence development

1. Introduction

The emerging role of technology for sustaining our society and environment is becoming crucial [1]. Although sustainability has been discussed in various fields, including manufacturing [2],

engineering [3], and environmental sciences [4], it is also a pressing concern in the field of technology, including computer science, information technology, and software engineering [5]. Sustainability consists of three fundamental dimensions, including social, economic, technological, and environmental aspects [4]. According to the Brundtland report from the United Nations (UN), sustainability acts to "meet the needs of the present without compromising the ability of future generations to satisfy their own needs" [6]. Sustainability concepts have now started expanding in the fields of technology development through computer science, IT, and Software engineering fields.

Software sustainability is generally reported as 'sustainable software', 'software sustainability', and 'sustainable development' [5]. Sustainable software refers to the capacity of software to be long-lasting and environment-friendly [7]. Sustainable software is defined as "software, whose impacts on the economy, society, human beings, and environment that result from development, deployment, and usage of the software are minimal and/or which have a positive effect on sustainable development" [8]. It is more related to the characteristics of software development's final products, which must include longevity and environmental friendliness [9].

Sustainable development describes the development procedure that must follow practices which are essential to achieving sustainability [5]. In particular, it focuses more on the operational description of activities that has to infuse sustainability in their practices to achieve the target goal of producing sustainable software [10]. Consequently, design and development of software by sustainable development practices are crucial [1]. In this decisive and competitive technological era, focus on sustainable development practices to achieve sustainable software has utmost importance [7].

Infusing sustainability in technology and software development is critical to achieving both objectives; software sustainability and sustainable development of software. Such infusion can be eventually possible with an in-depth understanding and awareness among students to address sustainability effectively during their degree projects and soon after in industry [11]. Providing awareness and understanding through sustainability education among students is essential. Sustainability education can provide in-depth competence to students for incorporating sustainability into future software development, which can eventually help to yield environmental friendly and sustained software [11].

The importance of competence development through technology education for sustainable development is highlighted in the Millennium Development Goals (MDGs). Pakistan is a country that upholds the importance of the MDGs and signed for their implementation. To achieve sustainable development goals, industry, academia, and researchers need to be change agents to realize the benefits of sustainability in the industry and among students.

A thorough investigation of the technology education curriculum is required. To address the pressing concern of sustainability education, the research questions are:

- To what extent does sustainability awareness exist among students?
- How much sustainability is infused across the technology education curriculum?

This research has undertaken a case study from a very populous and developing country—Pakistan. Education for sustainability and its awareness among students, if left unattended and ignored, can impact directly on students' skills, abilities, and performance. The lack of incorporation of sustainability education in technology development can lead to software crises [12]. To tackle this, there is a need to educate students in advance to build the required competence for addressing sustainability. In this context, a comprehensive investigation of the course curriculum is required. It is essential to determine whether technology education-related degree programs have sufficient sustainability content in their curriculum.

This study employed a mixed research methodology of qualitative investigation through document analysis and a survey through a questionnaire. A curriculum of technology education followed in Pakistan is taken for document analysis. Moreover, a survey is conducted among university students to investigate their awareness regarding sustainability.

The rest of the paper is organized into four sections. In Section 2, the literature on sustainability's definition in general and in the context of technology education is reviewed. Section 3 reports the research methods used in this research. Section 4 reports the results collected in this study. Section 5 presents a detailed analysis of the results, followed by a discussion of the results in Section 6. Lastly, Section 7 outlines the research conclusion, limitations, and future work.

2. Literature Review

This section reports the general concept of sustainability and from the perspective of technology development.

2.1. Sustainability in the Context of Technology Education

The concept of 'sustainability' refers to the capacity to survive over an extended period [5], considering environmental, social, and technological aspects to save future resources [12]. Earlier, Brundtland report from the United Nations (UN) refers to sustainability as " ... meet the needs of the present without compromising the ability of future generations to satisfy their own needs" [13]. Sustainable development is described as those acts and procedures that can develop a sustainable product [12]. Also, it is specified that sustainable development focuses on addressing the social, environmental, and technological sustainability aspects [14]. Sustainable development generally refers to two concepts: first, related to aspects that can generate a long-lasting product; second, related to sustainable practices that can sustain a product. Various fields have witnessed the importance of sustainability [15]. However, the literature reveals that academics and practitioners show an interest in sustainability for technology development [9].

Numerous studies have reported technology sustainability and generally denote it as 'green' or 'sustainable' technology [16]. Green technology refers to environmentally friendly technology with minimal or no effect on the environment [16]. Green technology is further categorized into four aspects, including energy efficiency, smartness in the system, green policies, and environmentally friendly products [16].

Sustainable technology is a long-lasting endeavour focusing on sustainable goals [17]. In 2013, Dick and colleagues defined sustainable technology in the context of software as "software, whose impacts on the economy, society, human beings, and the environment that result from development, deployment, and usage of the software are minimal and/or which have a positive effect on sustainable development" [8]. Some other researchers [18] linked the concept of sustainable technology with software development coding style. According to them, the coding style should focus on sustainable goals through sustainable development practices.

Hence, aspects of green and sustainable technology can be achieved through the development of sustainable software. Energy-efficient coding scheme optimized code and resource optimization are some of the important aspects of sustainability in software. Ignoring the sustainability aspects in software development can cause technology failure [7]. Such failure can become a cause of emerging sustainability issues regarding social, economic, and environmental aspects [19].

2.2. Education for Understanding Sustainability

Educating sustainability and providing awareness of it to students is crucial. In this regard, sustainability understanding of technology education can be nurtured from educational institutes. Universities all over the world are dedicated to achieving sustainability in terms of their operations, research, and curriculum [20].

Thus, diffusing sustainability in higher education (HE) for sustainable development is a recent [2] and a promising research area [20]. Therefore, educating sustainability among students must encapsulate the practices and strategies of energy efficiency, risk reduction, green computing, sustainable designs, climate change, and sustainable consumption of resources [3]. With the inclusion of such concepts in their education, student's competencies can be enhanced [11].

2.3. Significance of Sustainability Awareness

Awareness among students for sustainability is generally associated with the environment, especially related to pollution [21]. Having an awareness of sustainability among students can eventually contribute not only to understanding sustainability but also to contributing towards sustainable technology development.

Providing sustainability awareness to students requires educational institutes to adapt their vision, policy, teaching, and in particular their curriculum [22]. As the sustainability concept is expanding in the technology industry [23], the sustainable mindset of young graduates must be nurtured through education.

Although efforts have been directed towards highlighting sustainability education's importance [24], little attention has been given to investigating the inclusion of sustainability in technology education curriculum for students' competence development [22]. Addressing such key sustainable competencies among students is the imperative need of the industry. Therefore, there is a need to examine universities programs for inclusion of sustainability education in their curriculum. This research aims to investigate the level of sustainability diffusion in technology education-related programs along with the level of sustainability awareness of students.

To respond to the pressing concern of educating sustainability, two research questions are addressed: RQ1—To what extent does sustainability awareness exist among students? RQ2—How much sustainability is infused across the technology education curriculum? Each of the research questions is answered using a mixed research methodology. Section 3 describes the mixed methodology used in this research.

3. Research Methodology

A mixed research methodology is useful to explore findings from different perspectives [25]. Thus, a mixed research methodology is used in this study to investigate whether the sustainability-related courses are incorporated in the offered programs, and to what extent sustainability concepts are understood among students. First, the curriculum of the higher education commission (HEC) of Pakistan is taken for document analysis. This curriculum is selected because it is a standard document followed by universities all over Pakistan (Curriculum, 2017). Secondly, a survey through the questionnaire was conducted among university students to investigate their sustainability awareness. A mixed methodology is considered useful in a single study as it can aid in the validation of the research findings [25]. Detailed steps of the overall research methodology used in this research are shown in Figure 1. Moreover, the details of the document analysis and survey methodology are reported in the following section.

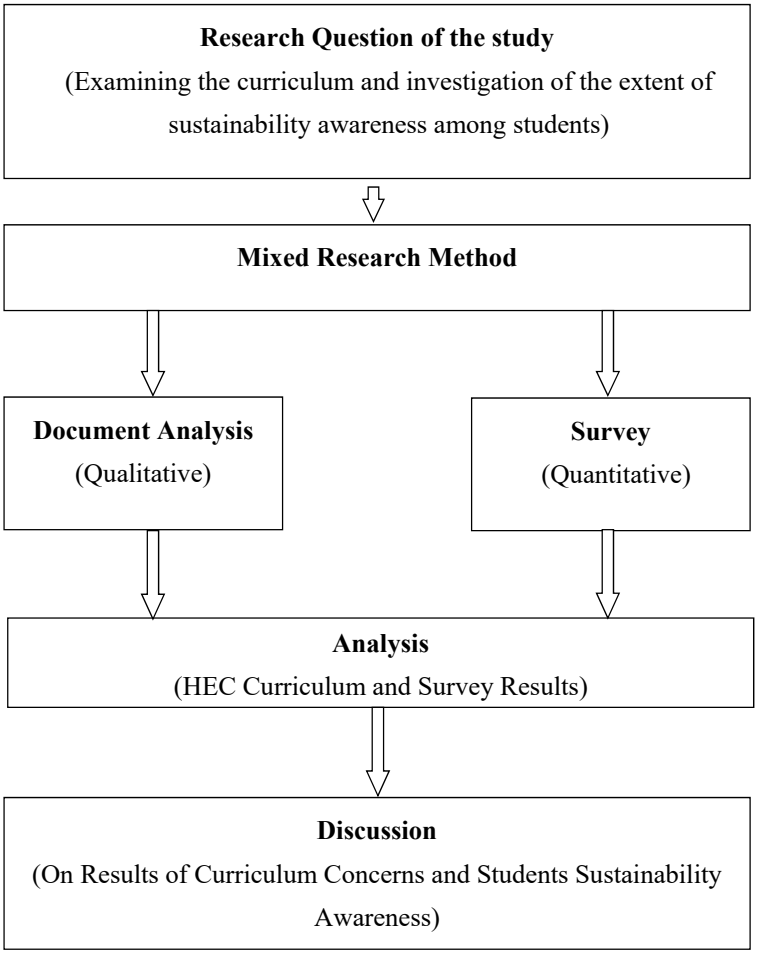

Figure 1. Steps of the overall research methodology.

3.1. Document Analysis

Document analysis is one of the qualitative research methods that help researchers to explore any topic [25]. Such analysis is instrumental in getting textual information and insights. Documents generally have three types, including public records, personal documents, and physical evidence [26]. Subsequently, the curriculum is a public record that is available for universities to follow.

As the aim of this document analysis is to examine sustainability's incorporation within the offered curriculum, the curriculum of the higher education commission of Pakistan is taken for document analysis. To analyze the curriculum document, a comprehensive guideline by O'Leary that focuses on diversified research is followed [26]. The adapted guideline is explained in detail in the following section.

3.1.1. Create a List of Text to Explore

The curriculum of the higher education commission of Pakistan is taken as a subjective document for this research. It was ensured that the updated version of this document was considered.

3.1.2. How the Text is Assessed

The criteria for document analysis consists of two phases. In the first phase, the offered courses are reviewed by their names. Courses which are explicitly or implicitly named sustainability are selected for further analysis. The second phase refers to the course contents

3.1.3. Acknowledge and Addressing Bias

Addressing bias is always challenging. However, the authors in this study have overcome this issue by considering a standard document for analysis.

3.1.4. Skills for Research

Skills are required to critically analyze the curriculum at the course and content level.

3.1.5. Data Relevance

Knowing the data's relevance before analyzing it is critical. Before starting the analysis of the whole curriculum, all semantics of sustainability are thoroughly checked to ensure the right analysis. Contents are also analyzed in the context of social, economic, and environmental sustainability aspects. Moreover, the topics of control of heat emission, energy efficient systems, code optimization, and resource utilization are also carefully analyzed in the offered courses.

3.2. Conduction of Survey

A survey was conducted to investigate the level of sustainability awareness among university students in Pakistan. The prime objective behind this is to examine their general level of understanding, as well as their understanding specific to their field. Moreover, the core is to examine students' proficiency in sustainability concepts and how they can use sustainability knowledge for technology education.

In this regard, all the higher education commission-registered universities of Pakistan were contacted via email. The survey invitations were sent to the concerned faculties to forward the questionnaire to their students in a hard or soft form. The survey questionnaire was adapted from the work of Penzenstadler et al. [27]. After modifying and aligning the contents of the questions with the aim of this survey, the developed questionnaire was validated for its content and face validity. Piloting of the questionnaire was done via fellow researchers, and their recommendations were amalgamated accordingly. The questionnaire validation was done through 'Average Congruency Percentage (ACP)', and 'Content Validity Index (CVI)'.

In this regard, six experts from academia were contacted. However, only three academicians participated. The predefined criteria of experts include; having more than ten years of experience, must be involved in software development, and have sound knowledge about sustainability.

In ACP, experts calculated the percentage of questions thought to be appropriate for them. In CVI, the content validity index for the individual item (I-CVI) was calculated. The questions were rated for their relevance. Expert 2 rated one out of 14 questions unrelated, resulting in 91.66% relevancy at their level. Expert 1 and expert 3 found all questions relevant, resulting in a 100% relevancy rate at their level. The experts' average value of congruency percentage is 95.5%, which is considered valid.

For CVI, the same experts were requested to assess each question's content relevance on a 4-point Likert scale. Where 1 = not related, 2 = somewhat related, 3 = related, 4 = strongly related. To decide the measures for relevance, the experts' rating 3 or 4 was considered as related, and 1 or 2 was considered as not related. The mean I-CVI value of questions by the experts was 0.87, and the Mean Expert Proportion was calculated as 0.87. The results of ACP and I-CVI show the high face and content validity of the questionnaire, hence certifying the quality of the instrument.

The questions and their responses by the survey participants are described in the Table A1 attached in Appendix A. A five-point Likert scale was used that consists of extremely aware, moderately aware, somewhat aware, slightly aware, and not at all aware. Distribution of the questionnaire among the target audience (students) was done in the form of hard copies and through the online survey tool, Google survey. As this research intends to focus more on a number of students, an online survey is much more useful because of its capability to collect data from diverse people and is efficient and cost-effective, as compared to the conventional survey.

3.2.1. Data Sources

A diverse target population was approached by sending an invitation to all major universities of the four provinces of Pakistan. The list of selected universities from the four provinces is shown in Table 1.

Table 1. List of selected universities.

Sr.#	Name of Selected Universities	Region (Provinces)
1	University of Karachi	Sindh
2	NED University of Engineering and Technology	Sindh
3	University of Engineering and Technology (UET)	Khyber Pakhtunkhwa (KPK)
4	University of Peshawar	Khyber Pakhtunkhwa (KPK)
5	University of Malakand, Chakdara	Khyber Pakhtunkhwa (KPK)

A total of 13 universities showed a willingness to respond to the invitations. The web questionnaire (Google Survey Form) was sent to the student's email addresses. Thus, a total of 153 responses from students (filled questionnaire) were collected over the five-month duration (June 2018 to October 2018). Upon validating the received responses based on predefined quality criteria, nine of the responses were discarded due to the incompleteness of the questionnaire. Finally, a total of 144 responses were considered for further analysis. The socio-demographic details of the participants are shown in Table 2. The demographic variables of the participants are Age, Gender, Degree/Course, Level, and Working Status.

Table 2. Demographic statistics of participants.

Demographic Detail		*n* (%)
Age	20–25 y	76 (52.77)
	25–30 y	68 (47.22)
Gender	Male	93 (64.58)
	Female	51 (35.41)
Degree/Course	Computer Science	48 (33.33)
	IT	43 (29.86)
	Software Engineering	53 (36.80)
Level	Postgraduate	68 (47.22)
	Undergraduate	76 (52.77)
Working Status	Not-Employed	91 (63.19)
	Employed	53 (36.80)

The timeline of receiving completed surveys is shown in Figure 2, where the vertical axis shows the number of responses and the horizontal axis describes the time frame in which responses are collected.

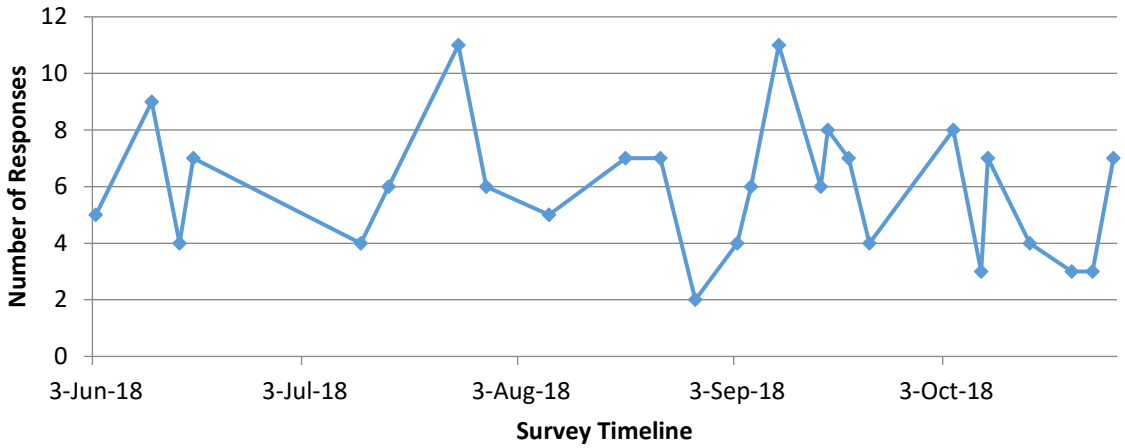

Figure 2. Analysis of survey sample.

3.2.2. Data Analysis

Data encoding was done using a statistical tool for data analysis. The frequency and weighted means were computed. The aim is to investigate the students' response rate against their level of sustainability awareness.

4. Results

This study examined the curriculum followed by universities in Pakistan; specifically, whether sustainability is incorporated in programs and course contents. The extent of sustainability awareness among students was also investigated.

4.1. Results from Document Analysis

A thorough review was conducted on the curriculum of technology education. After a careful review process (see Section 3.1), the details of programs and courses offered in various universities were identified. Table 3 shows the university names, faculty name, department, programs offered, and course contents from the perspective of sustainability in technology education-related disciplines and analysis of their course contents.

Table 3. Details of programs and courses found in various universities.

University/DAI Name	Faculty	Department	Program Offered	Courses Content with Perspective of Sustainability in Technology Development	Analysis of Courses
Air University, Islamabad	Faculty of basic and applied sciences	Department of Computer Science and Engineering	Undergraduate program (Bachelor of Computer Science)	Professional Practices in IT	Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology)
Allama Iqbal Open University, Islamabad (AIOU)	Faculty of Sciences	Department of Computer Science	Post Graduate Diploma in Computer Science (PGD(CS)) Bachelor of Science (Computer Science) MS Computer Science	Software House practices (offered in the Bachelor of science degree)	Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology)
Bahria University, Islamabad		Department of computer science ---------- Department of computer and software	BS computer science BS information technology MS computer science PhD. Computer science --------- BS Computer engineering BS software engineering PhD in software engineering	Professional Practices (offered in BS computer science)	Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology)
COMSATS Institute of Information Technology, Islamabad	Faculty of information and technology	Department of computer science	Bachelor of computer science (BSCS) Bachelor of Software Engineering (BSSE) MSCS MSIT MSSE	Professional practice (BSSE) Software Project Management (BSSE) Advanced software project management (MSCS and MSSE)	The professional practice course is specifically designed to critically analyze and evaluate the consequences of computing on individuals, organizations, and society. This course will help to examine the Information Technology professionalism, ethical decision making, and codes of ethics. With the help of these students will analyze situations of computer use and technology and policy proposals, identifying the salient issues and evaluating the reasoning about them. Software Project Management course covers management techniques to plan, execute, and control software development projects. Upon completion, participants should be able to estimate and plan effectively monitoring the process and perform a project risk assessment for a software development project. They will also study how software development is integrated with other business activities and how social and environmental factors impact development.

Table 3. *Cont.*

University/DAI Name	Faculty	Department	Program Offered	Courses Content with Perspective of Sustainability in Technology Development	Analysis of Courses
Dawood University of Eng. & Technology, Karachi	Faculty of the computer system and engineering	Department of computer system engineering	BE(CS)	NIL	NIL
Federal Urdu University of Arts, Sciences & Technology, Islamabad	Faculty of science and technology	Department of computer science	The undergraduate and postgraduate program	NIL	NIL
International Islamic University, Islamabad	Faculty of Basic and Applied Sciences	Department of computer science and software engineering	BS Computer Science, BS Software Engineering MCS Computer Science, MS Computer Science MS Software Engineering PhD in Computer Science PhD in Software Engineering	NIL ---------- Software engineering economics, software project management (BSSE) ---------- Software engineering management, Human factors in computing (MSSE)	
National University of Modern Languages, Islamabad (NUML)	Faculty of engineering and computer science	Department of software engineering, Department of computer science	BSSE ---------- BSCS, MSCS	Software project management ---------- Software project management (BSCS)	
National University of Sciences & Technology, Rawalpindi/Islamabad (NUST)	School of electrical engineering and computer science (SEECS)	Department of computing	BESE BSCS MS and PhD in Computer Science, MS and PhD in IT,	Software engineering economics, software project management (BESE) ---------- Software Project Management, Software Engineering Economics (BSCS) NIL ---------- NIL	
Pakistan Institute of Engineering & Applied Sciences, Islamabad (PIEAS)	Faculty of Computer and information science	Department of Computer science	BS in Computer and Information Science M. Phil in Computer Science PhD in Computer Science	NIL	

Table 3. *Cont.*

University/DAI Name	Faculty	Department	Program Offered	Courses Content with Perspective of Sustainability in Technology Development	Analysis of Courses
Quaid-i-Azam University, Islamabad	Faculty of natural science	Computer science	PhD in Computer Science MPhil in Computer Science MS in Information Science & Technology MSc in Computer Science BS in Computer Science	NIL ---------- Social and Organizational Issues of Information, Economics and Business in the Web (M.Phil CS) ---------- Software Management & Economics (MSIS and Tech) Emerging Trends in Software Development, Social Issues in Information Technology, software project management (MS CS) ---------- NIL	
Virtual University of Pakistan, Lahore	Faculty of computer science and information technology	Department of computer science and information technology	BS in Computer Science BS in Information Technology BS in Software Engineering Master in Computer Science Master in IT MS in Computer Science PhD in CS	NIL ---------- NIL ---------- Software project management ---------- NIL ---------- Software project management ---------- NIL ---------- NIL	

4.2. Survey Results

The aim of conducting a survey is to investigate the students' level of awareness for sustainability in technology education. The summarized results of 144 respondents in the survey are shown in Table 4. The table comprises 'questions', 'optimistic', 'pessimistic', and 'impartial'. Furthermore, the detailed questionnaire and survey responses are attached in Appendix A.

Table 4. Result of questionnaire responses.

Sr. #	Sustainability Dimensions	Optimistic %	Pessimistic %	Impartial %
1	Environmental Sustainability	31.59	47.74	20.31
2	Social Sustainability	38.71	41.31	19.96
3	Economic Sustainability	39.1	40.74	20.1
4	General Understanding of Sustainability	36.1	43.05	20.83

The detailed analysis of the results from document analysis and survey is subsequently described in the following section. Frequency of survey responses is calculated. Data analysis is made stronger when the frequency distribution is provided. The frequency distribution demonstrates the per cent of responses for each question that match the rating scale utilized by respondents to give their answers to the survey. Both analyses aimed to answer the research questions of this study.

5. Analysis

Most universities have lack dedicated sustainability programs. However, some of the universities have taken the initiative of offering courses on the graduate and postgraduate level. It is found that at the graduate level, courses such as 'professional practice', 'software project management', 'Software engineering economics', and 'software house practices' are offered.

Analyzing the content of the graduate level courses, it is observed that little has been incorporated related to sustainability understanding and its importance. In other words, a small number of courses have sustainability aspects incorporated in their content. The details of the course content are mapped by sustainability dimensions and are shown in Figure 3.

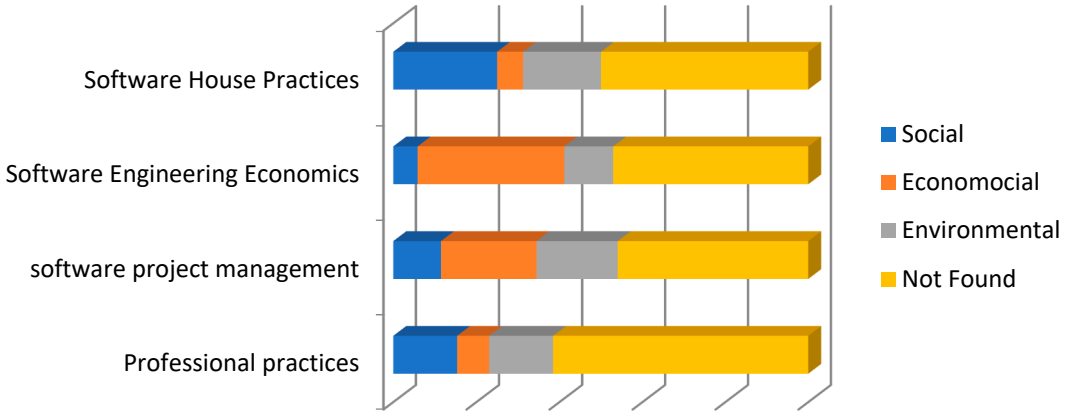

Figure 3. Mapping of graduate course contents by sustainability dimensions.

It is observed that the course of 'professional practices' has general ethics content that must be followed during software development. However, little has been covered in terms of social, environmental, and economic sustainability. The course of 'software project management' generally covers project management concepts and skills, but very little is covered relating to sustainability concepts. This course ignores the much-needed understanding of concepts of economic and environmental sustainability. 'Software engineering economics' is targeted towards economic

sustainability only and lacks social and environmental sustainability aspects. The 'software house practices' course incorporates management and technical aspects of how to run software houses. This course covers the concepts of social sustainability, but other aspects are less covered.

The offered courses for postgraduates are 'Advanced software project management', 'Software engineering management', 'Human factors in computing', 'Social and Organizational Issues of Information, Economics and Business in the Web', 'Software Management & Economics', 'Emerging Trends in Software Development', and 'Social Issues in Information Technology'. Surprisingly, fewer courses are offered related to sustainability in software development. However, after carefully analyzing the meaning and semantics of the titles of the offered courses, few courses seem to address sustainability.

The dimensions of social, economic, technological, and environmental sustainability are less targeted. Furthermore, it is observed that there is a lack of attention towards courses offering 'Energy efficient programming', 'energy-driven coding standards', and 'policy development for heat conducing environment'. The detailed results of the postgraduate course content related to sustainability dimensions are reported in Figure 4.

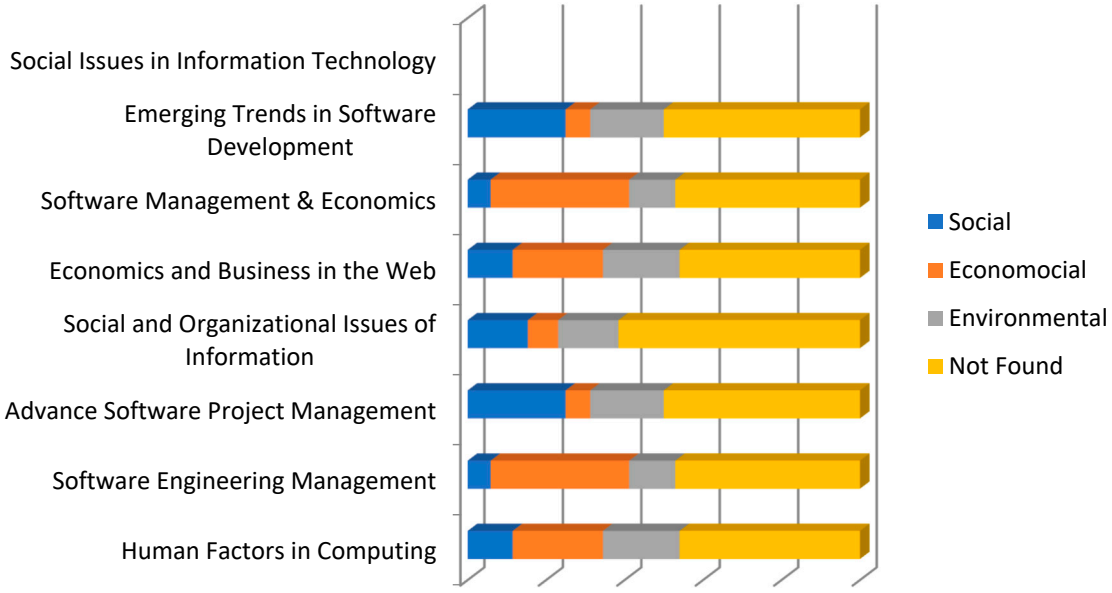

Figure 4. Mapping of postgraduate course contents by sustainability dimensions.

The thorough analysis of postgraduate course content shows that the 'Social Issues in Information Technology' and 'Social and Organizational Issues of Information', and 'Economics and Business in the Web' courses focus more on social aspects of sustainability. Similarly, courses of 'Emerging Trends in Software Development' and 'Software Management and Economics' cover economic aspects. Moreover, human aspects of sustainability are covered in the courses, but environmental sustainability is lacking. It is argued that both graduate and postgraduate courses have generally incorporated the concepts of the economics of software, cost of software development, and the benefits of infusing software into organizations. Other courses have focused on social and organization issues, leaving behind the aspects of economic and environmental sustainability.

The survey results, as reported in Appendix A, show the awareness of students regarding sustainability and its dimensions. According to the statistics, 36.37% of the respondents were aware of sustainability and its dimensions. 43.32% of the respondents were unaware of the concepts of sustainability and its dimensions. However, 20.30% of the respondents were partially aware of sustainability and its dimensions. Figure 5 presents a graphical representation of the survey findings.

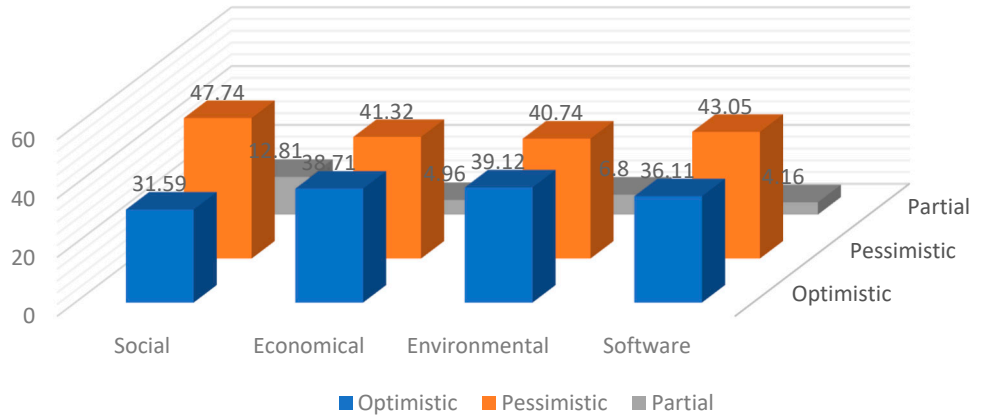

Figure 5. Graphical representation of survey findings.

6. Discussion

Sustainability conceptualization and its practices in the technology development field are necessary for addressing the industry's current and future needs [28]. To address the concern of the industry, it has been argued that an appropriate curriculum should provide sustainability education to students of related technology disciplines [29].

It is observed that the current curriculum is unable to incorporate sustainability to create environment-friendly systems via less heat emitting technology, to have more economically sustainable solutions, and to have sustained technological systems. Efficient coding schemes and the importance of technology to increase the quality of human life and well-being are two concepts which are entirely missing from the curriculum. These concepts have to be incorporated into the curriculum to prepare students to be better future professionals.

If sustainability concepts are not comprehensively covered in the offered curriculum, the potential capabilities of students can be undermined. Moreover, it can also result in the misuse of energy resources, heat emission to the environment, carbon emission, and overbudgeted technology development [30]. Thus, the results found in this analysis highlight an urgent need to revisit the curriculum to incorporate the much-needed sustainability aspects into technology-related courses.

Our survey results also validated the findings of the document analysis of the curriculum followed in universities. The results confirm that most students do not have a general understanding of sustainability and are unaware of the significance of considering sustainability in technology development.

Students lack understanding of how sustainability is infused in the IT and software field and what benefits are associated if it is adequately incorporated [31].

If sustainability is not properly addressed in the curriculum and among students, it may eventually contribute to the failure of the technology development industry. It is concluded that students must respond immediately to the issue of technological, social, and environmental sustainability. In other words, there is a strong need for periodically revisiting the curriculum related to technology education (software engineering, computer science, and IT fields) to incorporate sustainability to enhance students' knowledge.

The amalgamation of sustainability could eventually help students to build capabilities to act as change agents to actively incorporate sustainability aspects directly or indirectly in technology development fields. As a result, energy efficient software, code optimization, risk reduction, green computing, and pro-environmental sustainable development can be achieved. Moreover, faculties also need to play a pivotal role in educating students about sustainability in technology development. Their teaching styles and methodologies must incorporate approaches through which software sustainability can be demonstrated. Furthermore, faculties can motivate students to focus on sustainability aspects in their degree projects, which they can continue later in their professional career.

University management must develop policies that support sustainability. Green campuses and 'go green' are some of the initiatives that universities all over the world are focusing on. These initiatives can act as a foundation to bring awareness about sustainability in all fields. Universities must also organize seminars and workshops that can highlight the importance of sustainability in the information and communication technology and software engineering fields.

7. Conclusions

To respond to the challenging nature of sustainability in technology education, students need to be educated and well aware of sustainability dimensions. This research aimed to explore the development of students' competence in technology education (IT, computer science, and software development) through investigating their awareness of sustainability, and to investigate how much sustainability education is infused into the technology education curriculum. A thorough qualitative analysis was performed using document analysis by taking the HEC's recent curriculum to analyze the programs offered and their course contents through the lens of sustainability. A survey was also used to investigate the sustainability awareness of students.

It is found that the curriculum is yet to incorporate the essential aspects of sustainability into its programs and courses. Upon detailed analysis of the offered courses, it was found that sustainability contents are not adequately addressed. The survey analysis also revealed that students enrolled in technology education-related disciplines are not aware of sustainability concepts.

There is an urgent need to raise technology-related sustainability awareness among students through education. The curriculum must include sustainability and its dimensions for competence development. Furthermore, industries should conduct training and workshops to guide students.

Although the document analysis was conducted on the latest HEC curriculum, there is a possibility that the researchers may have overlooked the reported content. A small pool of documents advocates 'biased selectivity'. In an educational institution context, the available materials are expected to be aligned with the institution's policies and principals. The analysis of courses and their content is done on the basis of what is provided to the readers, which limits the generalization of the findings. Furthermore, a survey was conducted comprehensively; however, the sample size was a limitation, which can be further enhanced in future research.

A similar study should be conducted for other disciplines, such as Law, Politics, Policy and Planning, Journalism, Business, and Architectural Design. Future researchers should investigate the extent of sustainability awareness among the students of these other disciplines.

Author Contributions: Conceptualization, H.H.K. and M.N.M.; methodology, H.H.K. and M.N.M.; data collection, M.N.M.; formal analysis, H.H.K. and M.N.M.; writing—original draft preparation, H.H.K. and M.N.M.; writing—review and editing, A.G.C., F.A.G., Y.A. and J.K.K.; visualization, Y.A.; project administration, J.J.K.; funding acquisition, J.J.K.

Acknowledgments: The research A.G.C. and J.J.K. have been supported by the EU project "Sustainable Process Integration Laboratory—SPIL", project No. CZ.02.1.01/0.0/0.0/15_003/0000456 funded by EU "CZ Operational Programme Research, Development and Education", Priority 1: Strengthening capacity for quality research.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Survey Resutls.

Sr. #	Questions	Sample Size of Survey Questionnaire: 144							
		Optimistic			Pessimistic			Impartial	
		EA	MA	Optimistic %	SA	NAA	Pessimistic %	SWA	%
1	Are you familiar with the concept of environmental sustainability?	24	27	35.42	38	26	44.44	28	19.44
2	The environment-friendly technology can contribute to a healthy environment.	18	37	38.19	41	19	43.06	26	18.06
3	Energy efficient technology is the contributors towards sustainable environment.	15	24	27.08	38	28	45.83	39	27.08
4	Technology can emit heat in environment.	14	23	25.69	42	41	57.64	24	16.67
5	Technology can be the main driver that can have social influence.	19	21	27.78	33	37	48.61	34	23.61
6	Technology can provides automation to various business sectors to contribute to society.	35	38	50.69	32	20	36.11	19	13.19
7	Technology can aid to live a better and healthy life.	18	28	31.94	28	34	43.06	36	25.00
8	Technology contributes to society by providing information and learning.	26	38	44.44	37	17	37.50	26	18.06
9	Technology can produces economical solutions in industry.	21	32	36.81	37	23	41.67	31	21.53
10	Technology can help to increase productivity of organizations.	26	38	44.44	33	19	36.11	28	19.44
11	Technology can contribute for economical sustainability.	21	31	36.11	35	29	44.44	28	19.44
12	Technology to be sustained over a long period of time is the success of the software.	31	38	47.92	31	17	33.33	27	18.75
13	Technology can be sustained by integrating sustainability aspects in software engineering?	18	24	29.17	36	35	49.31	31	21.53
14	Sustainable Technology addresses sustainability practices including code optimization, resources utilization and energy efficient coding.	22	23	31.25	38	29	46.53	32	22.22

Ellipsis: EA, Extremely Aware; MA, Moderately Aware; SWA, Somewhat Aware; SA, Slightly Aware; NAA, Not At All Aware.

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