

EMPIRICAL INVESTIGATION OF VALUE-FOCUSED THINKING IN  
SOFTWARE ENGINEERING EDUCATION

MUHAMMAD UMAR SULTAN



NATIONAL UNIVERSITY OF MODERN LANGUAGES

## THESIS AND DEFENSE APPROVAL FORM

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Muhammad Umar Sultan

Submitted By:

MSSE

Title of the Degree

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Registration #:

Software Engineering

Name of Discipline

Dr. Javeed Iqbal

Name of External Examiner

Signature: \_\_\_\_\_

Dr. Fazli Subhan

Name of Internal Examiner

Signature: \_\_\_\_\_

Dr. Huma Hayat khan

Name of Research Supervisor

Signature: \_\_\_\_\_

Dr. Nauman Malik

Name of Co-Supervisor

Signature: \_\_\_\_\_

Dr. Muzafar Khan

Name of HoD (SE)

Signature: \_\_\_\_\_

Dr. Basit Shahzad

Name of Dean (FE&CS)

Signature: \_\_\_\_\_

Prof. Dr. Muhammad Safeer Awan

Name of Pro-rector Academics

Signature: \_\_\_\_\_

July 15<sup>th</sup>, 2021

“I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Master of Science in Software Engineering (MSSE)”

Signature : \_\_\_\_\_  
Name : Dr. Huma Hayat khan  
Date : July 15<sup>th</sup>, 2021

Signature : \_\_\_\_\_  
Name : Dr. Noman Malik  
Date : July 15<sup>th</sup>, 2021

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MUHAMMAD UMAR SULTAN

A thesis submitted in fulfillment of the  
requirements for the award of the degree of  
Master of (Software Engineering)

Department of Software Engineering  
National University of Modern Languages

JULY 2021

## DECLARATION

I declare that this thesis entitled “*Empirical investigation of value-focused thinking in Software engineering education*” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : \_\_\_\_\_  
Name : Muhammad Umar Sultan  
Date : July 15<sup>th</sup>, 2021

*This thesis work is dedicated to my parents and my teachers throughout my education career who have not only loved me unconditionally but whose good examples have taught me to work hard for the things that I aspire to achieve.*

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## **ABSTRACT**

The number of software development projects fail every year which is considered as a big threat to the software industry. Software developers are unable to complete their projects within the allocated time and resources due to a lack of their understanding towards “value-focused thinking”. Value-focused thinking is considered to focus the choices on the vital activities that must happen before solving the problem. To have successful software development, there is a need to build the understandability of value-focused thinking among the students during the education of software engineering. Based on the understandability of value-focused thinking practices, the students play an important role in the industry and deliver a high-quality product within the resources and time. In this study, survey methodology is used. A questionnaire as an instrument is used. This study is set out to discover the concept of value-focused thinking in the software engineering education department. In doing so, this study provides the detail about the extent of awareness about value-focused thinking among the students and faculty of the software engineering education department. Besides, three practices of value-focused thinking are explored and reported with the ways to diffuse these practices in the software engineering education departments. This research is providing a sound contribution to the software engineering body of knowledge by providing an approach that can diffuse values in the software engineering education curriculum. This research will help software engineering students to develop skills for applying value-focused thinking practices in software development.



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## LIST OF ABBREVIATIONS

VFT	-	Value-Focused Thinking
SWEBOK	-	Software Engineering Book of Knowledge
SEI	-	Software Engineering Institute
SE	-	Software Engineering

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

This chapter documents the background of the research, problem statement, goal, research questions, and objectives along with the research scope, contributions, and significance.

#### **1.2 Overview**

Value-focused thinking is a kind of mixture of a qualitative and quantitative method for cohesive system investigation. In the study of systems and technology, VFT highlights the value as the center. In the decision-making procedure, the VFT modeling is simple and easy to work. For instance, through the value of the center of gravity investigation of decision-making in the more important attributes, which can more truly reflect the decision-makers on the program's preference. The VFT provides decision-makers with the idea of decision-making. It can grasp the practices of decision-making in the decision-making process, reducing the decision-making steps, and saving the decision-making time [1].

### 1.3 Background of Research

Value-focused thinking (VFT) places values at the decision-making center. Explicit values make it easier to classify existing alternatives, generate new alternatives, communicate and negotiate, and identify new opportunities for pursuing decision-making [2]. Value is everything the customer is willing to pay for and Waste is any activity that produces no value for the customer or user. The main objective of software engineering is to make and maintain prime quality software-intensive systems and services that provide value to their users and society as a full [3]. Value-focused thinking could be a more creative method since it focuses on the various decision objectives and the way as many alternatives as possible is also generated from them [4]. A problem with a decision is when an incident happens and you have to choose how to respond; a decision opportunity is when you consciously decide to move away [1]. Additionally, since software and software development are pervasive (e.g., any product nowadays is supported or enabled through software and changes to societies and communities are often driven by innovations through software), value aspects in software and its Software Engineering are getting even more essential [2].

At an early stage within the process, the center of attention is about objectives, intentions, desired results, and decision advantages, and the chief tries to explore unknown solutions to the matter. It's argued that this time of departure makes it easier to attain the required consequences of the choice. By using value-focused thinking, one starts with the simplest potential outcome so one works hard to realize it [4]. In the process of development of Value-Focused Software (VBS), a revolutionary concept is applied to achieve economic leverage. High uncertainty occurs about the result after it introduces an innovative idea [5]. Furthermore, software engineering activities have to add the maximum amount of value as possible to support developers in completing their tasks given time, cost, and resource constraints. As an example, developers may "value" tools that help them identify the simplest set of test cases but may consider long planning meetings as a "waste" because they are doing not help them deliver a high-quality product [2].

Therefore, the value may be a much broader concept and may be checked out in terms of the software package or service value, but is additionally related to the artifacts, processes, practices, and principles of software development and with development organizations themselves, its teams and even individuals [2]. When designing these systems, the level of uncertainty is very high. The involvement of relevant stakeholders in the achievement of desired results is highly desirable in the Phase of production of those systems [5].

Also, as software engineers, we'd like to handle broader human and societal values additionally to what the software development community typically values (automation, productivity, quality, low cost, etc [2]. Processes of Value-Focused Software Engineering (VBSE), have a significant impact on VBS software development efficiency. The value-focused approach combines the value principles with the current and changing Software Engineering (SE) doctrines and all these doctrines support one another in the development of a new paradigm. Researchers however define the word value in terms of the economic or monetary value of something, with time "the scope of VBSE research expanded to include non-economic and monetary aspects of value" [5].

Barry Boehm and his mates describe VBSE as "the explicit concern with value concerns in the application of science and mathematics by which computer software properties are made useful to humans" [5]. As in Lean development, any activity that's not considered to feature value (to the customer but also developers) is also considered as waste and causes potential risks (e.g., frustrated customers and developers, project delays). However, explicit value and waste considerations must an outsized extent been neglected in software engineering within the past. specifically, while cost, safety, availability, and security have received some attention, broader human values (and the notion of import beyond business, economic and technical value) like compassion, social responsibility, and justice are a side concern in software engineering [2].

In one of the initial applications, VFT was applied for strategic planning at British Columbia Hydro to discourse some key issues. VFT has been applied to recognize the value of e-commerce to the customer's Protection applications of VFT range from rifle selection for the armed forces to the upgrading of core competencies of the Air Force[6]. Problem structuring through VFT is done creatively so that stakeholders have a better understanding of the objectives and opportunities of the decision problem. During the process, stakeholders are encouraged to actively interact in building a map that will identify the intended objectives of the decision problem from their perceived values. In this map, objectives are differentiated into “means” objectives and “fundamental” objectives through the relationship between the cause and effect of contextual variables indicated by stakeholders [7].

Value-focused thinking calls for spreading the decision context from a narrow alternatives-thinking (in means- objectives) towards the attention of fundamental objectives. Those essential objectives of a decision-maker need to be intelligible with the strategic objectives of the decision-maker and the strategic decision context [8]. The VFT method was employed to attain its objectives and to better understand how users can maximize their awareness in terms of safety and confidentiality, and also issues and threats in SNS. VFT is a decision method developed by Keeney, where values are the main focus of the decision-making process. One principal advantage of this approach is that better alternatives for a decision problem can be produced once objectives have been recognized over the more old-style method where alternatives are first identified after which the objectives are specified [9].

The value-focused thinking method provides a method to recognize values and structure the recognized values systematically. Values are defined as principles used for assessment by customers. Values that are of concern are made explicit by the identification of purposes. An objective is a statement of something that one wishes to achieve. VFT method can result in a means-ends objective network that can represent essential ideas and means purposes [10].

## **1.4 Problem Statement**

To have successful software development, there is a need to build the understandability of value-focused thinking among the students during software engineering education. Students may “value” tools that help them find the best set of test cases, but may consider long planning meetings as a “waste” because they do not help them to provide a high-quality product. To overcome this problem there is a need to build the understanding of the value-focused thinking in the student during the study through applying value-focused thinking practices in the project. Based on the understandability of value-focused thinking practices, the students play an important role in the industry and deliver a high-quality product within the resources [3].

## **1.5 Research Questions**

This study comprises three research questions.

RQ1: What is perceived awareness of value-focused thinking in software engineering education?

RQ2: What practices make value-focused thinking in software engineering education?

RQ3: How these practices can be diffused in software engineering education?

## **1.6 Research Objectives**

This study comprises three research objectives.

Objective 1: To identify awareness about value-focused thinking to students and faculty.

Objective 2: To identify the practices which make the value base thinking in software engineering education.

Objective 3: To generate an approach for diffusing value-focused thinking in software engineering education.

### **1.7 Scope of Research Work**

The scope of this research is restricted to the following.

1. This research was focus on value-focused thinking practices in software engineering education.
2. For Survey conduction, the target audience for the survey was only faculty and students of the software engineering department.
3. This research was targeting the audience of NUML, ISLAMIC, NUST UNIVERSITY, FAST UNIVERSITY, BAHRIA UNIVERSITY, and COMSAT University.
4. The number of samples for a student is including students from the 4th semester to the 8<sup>th</sup> semester.
5. The number of samples for faculty is including all faculty of the Software engineering department.

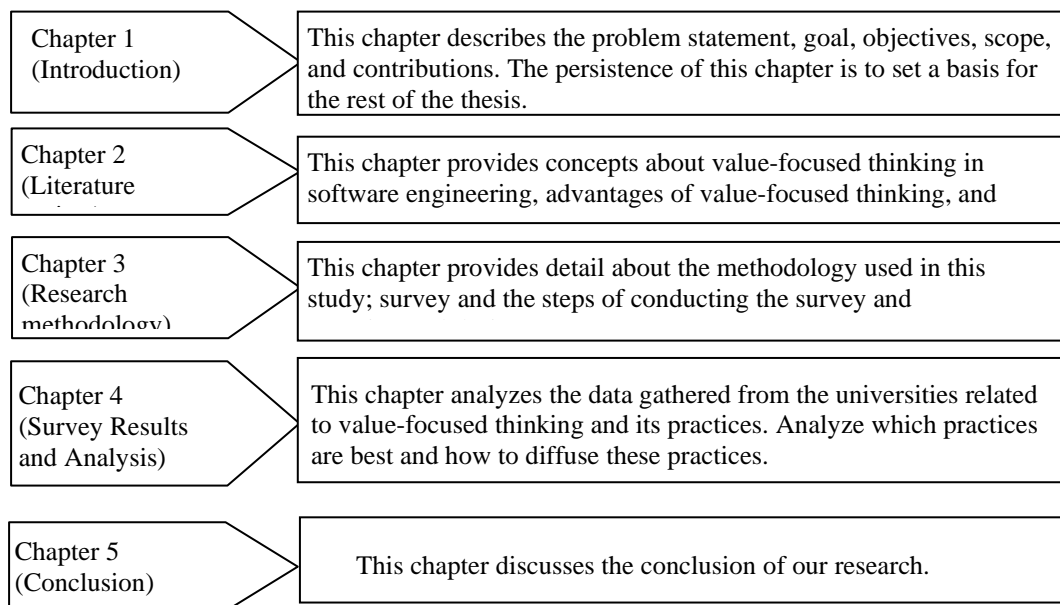
### **1.8 Contribution of the study**

The contributions of this study are mainly towards the advances in the Software Engineering Body of knowledge-SWEBOK [8].

1. The first contribution of the study was done by providing the perceived awareness level of value-focused thinking in software engineering education.
2. The second contribution was done by providing the list of practices for having focused thinking in software engineering education.
3. The third contribution of the study was done by diffusing the value-focused thinking practices in software engineering education.

4. This research is providing a sound contribution to the Software Engineering Body of knowledge (SEBOK) by providing an approach that can diffuse values in the software engineering education curriculum.
5. It is believed that this research helps the software engineering students to develop a skill, how to apply value-focused thinking practices in software development.

## 1.9 Outline of thesis



**Figure 1.1** Outline of thesis

### 1.10 Chapter summary

This chapter described the introduction of the problem area by reporting the problem background and explaining that acquiring and understanding the requirements is one of the most challenging tasks in software development. The chapter describes research questions, objectives, scope, contribution, and significance of the study.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

In the previous chapter, reported the outline of the study where the problem statement, the background of the problem, research questions, scope, contribution, and significance of the study is stated. This chapter more extends it by exploring the available work related to the research and problem area.

This chapter concerns the proper role of values and the formation of values in decision-making processes. Suggest values should play a more central role in authenticating decision-making processes than is currently the case. By using value-focused thinking, a style of thinking that focuses more and earlier on values, it may be practical to imagine more attractive decision problems than those that currently face us. In other words, value-focused thinking should lead to good alternatives than those produced by existing "conventional" procedures.

#### **2.2 Value-Focused Thinking**

According to Keeney, Value-focused thinking (VFT) is a procedure that can help to identify what is needed in an interface for a specific application and can be used to compare different potential interface solutions or can be used to judge how well an interface currently meets the customer's needs. The method provides a means to



disclose and address the multiple objectives of an interface design effort. Considering that all development efforts have resource constraints, such a methodology would help drive a project in the right direction [11].

In contrast, value-focused thinking is a more creative technique since it focuses on the different decision objectives and how as many alternatives as likely may be generated from them. At an early stage in the process, the center of attention is set on objectives, aims, desired results, and decision advantages, and the decision-maker tries to discover unknown solutions to the problem. It is said that this point of departure makes it easier to achieve the desired penalties of the decision. Factors such as inspiration, participation, sureness, and knowledge all play a part in such a process [12].

In another study, some major sub-tasks for decision-making were discussed below [13].

The major sub-tasks for decision-making include the following.

### **2.2.1 Identify Problem**

The representative must identify that a decision must be made. This study uses the term "problem" here to denote any goal that initiates the decision process. A chance could just as well activate the task of decision-making. Thus, either losing your job or winning the draw might well require you to make decisions [13].

### **2.2.2 Identify Alternatives**

Once the problem has been recognized, the agent must regulate what alternative actions are possible. The process underlying the choice of alternatives is by no means simple. Case-based reasoning provides one method to this task [13].

### **2.2.3 Choose Usual Action**

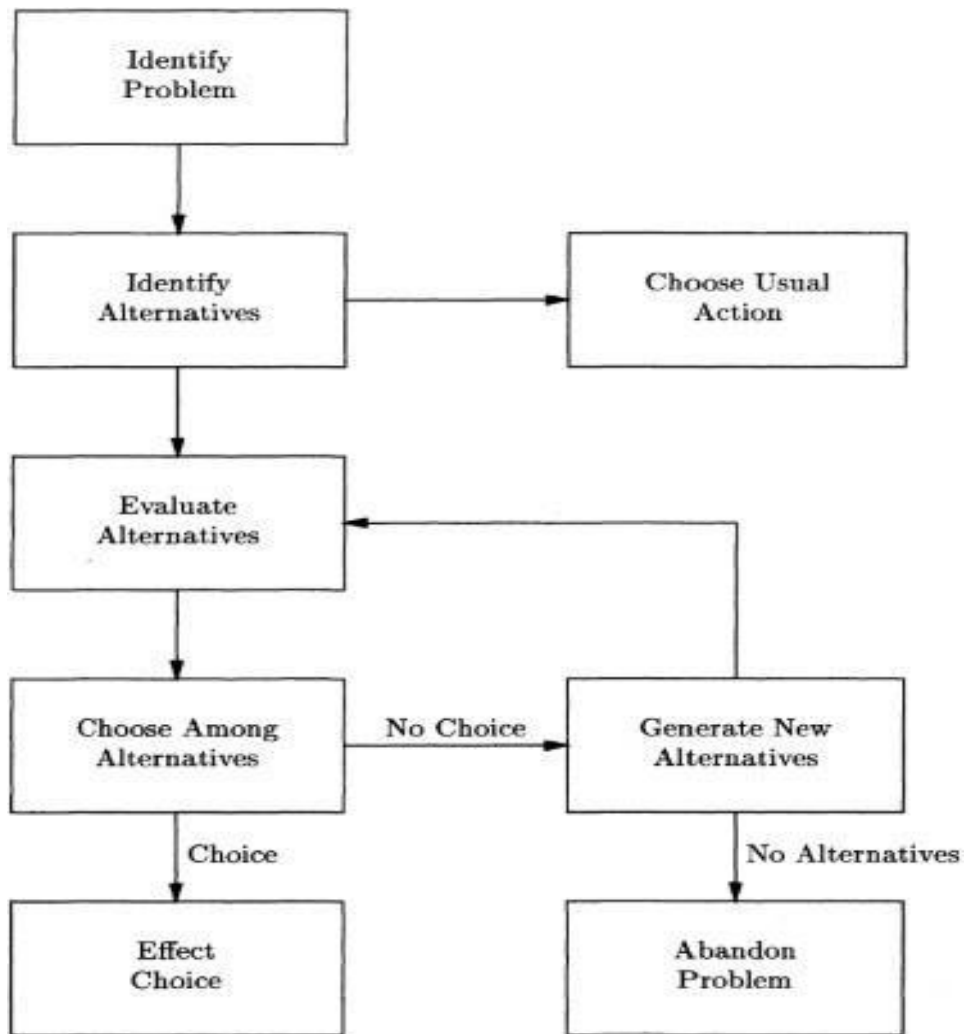
Many common circumstances in life may have a standard reply that finesses the issue of choice. An agent may continuously order the same thing for lunch, or continuously wear the same pair of shoes. Following this branch in effect avoids the creation of a decision. From the perspective of computational effort, selecting the usual action is very effective [13].

### **2.2.4 Evaluate Alternatives**

Presumptuous that there are numerous reasonable alternatives, the representative must assess the options. The process of assessment may rely on factors including penalties and likelihoods of outcomes, preferences, and experience [13].

### **2.2.5 Select Among Substitutes**

Implicit in the calculation process is a metric by which the choices may be ranked. If there is only one position possible, then the choice with the maximum position is selected. If more than one position is possible, then there must be other ways of selecting among the rankings [13].



**Figure 2.1** Decision-Making Process [13]

### 2.2.6 Effect Choice

When a choice has been finished, it needs to be put into action. The next step may be the execution of a plan, that is, the agent can perform an action that will achieve the goals of the choice. If that action is surprising or has adverse values for others, the agent may be expected to provide a clarification for the decision. Decisions involving accepted goals are likely to need clarifications. Many decisions will require reasonings in addition to actions. For example, when a judge reduces a verdict, he or she will usually provide clarification for his or her conclusion. The verdict by itself constitutes an effective action, however, the explanation serves to justify the conclusion [13].

Additional times, the negotiator will not have the means or authority to take direct action but may appeal to others to act. The reasoning of the agent's decision becomes a dispute aimed at persuasion others to action. For instance, newspaper reporting may advocate certain situations on public issues without directly disturbing those issues. Or a committee may make a recommendation that may or may not be accepted by the larger authority. In these cases, the explanation plays a central role in affecting the decision [13].

### **2.2.7 Generate New Alternatives**

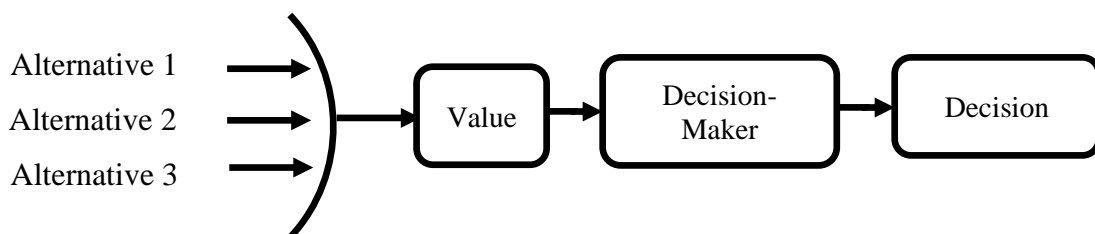
In some cases, the best alternate may not be good sufficient. That is, the position procedure may propose a course of action that is unacceptable. In this case, the agent may wish to try again, by generating new alternatives, which will then be evaluated as before [13].

### **2.2.8 Abandon Problem**

If no acceptable alternative is nominated, the negotiator may choose to abandon the original problem. This process could be considered as simply another alternative that is available for most, if not all, decision problems. This analysis of the decision process is an attempt to convey a broad and general scope for decision-making [13].

In sum, the decision-maker's set of values should be the guide in analyzing decisions. "Values," in this context, mean purposes, desires, ends, "what is important," "what is of concern," "what satisfies"—in short, what the person wants to achieve through the decision [14]. VFT is a kind of mixture of qualitative and quantitative techniques for combined system examination. On the examination of system and technology, VFT highlights the value as the center. In the decision-making process, the VFT modeling is modest and easy to operate, which is extensively used in three aspects: company plan, decision model invention, and defense acquisition. VFT is the common goal of the present decision-making model, and the VFT also was used to regulate the

weight in numerous attribute decision-making difficulties. For example, through the value of the center of gravity examination of decision-making in the more important characteristics, which can more truly reproduce the decision-makers on the program's preference. The VFT provides decision-makers with the idea of decision-making. It can grip the key factors of decision-making in the decision-making procedure, dropping the decision-making steps, and saving the decision-making time. The application of the VFT method in the decision-making process can be simply described in Figure 2.1 [1]. The alternatives are defined as the ways of achieving the objectives of the decision-maker. Once the objectives are known, new alternatives that satisfy them can be sought; that is, this perspective permits enlargement of the context of the decision. Keeney calls this approach “value-focused thinking” (VFT), whereas the traditional approach is called “alternative-focused thinking” (AFT). Value-focused thinking should provide, the following benefits in decision analysis, among others: (a) Alternatives with more innovative characteristics are included. (b) The range of alternatives included becomes wider. (c) The upcoming penalties of decisions are taken more into account. (d) Replacements that at first glance would not be considered are combined. (e) More desirable consequences are considered [14].



**Figure 2.2** VFT Decision-making process [1]

Value-focused thinking (VFT) is thinking to guide decision-makers. It has three major ideas: start with values, use values to produce better alternatives, and use values to estimate those alternatives [15].

### **2.2.9 Start with Values**

Instead of starting with replacements, start with the choice-making and investors' aims [15].

### **2.2.10 Create better Alternatives**

Once you've recognized values, use them to create better alternatives [15].

### **2.2.11 Use Value to Evaluate Alternatives**

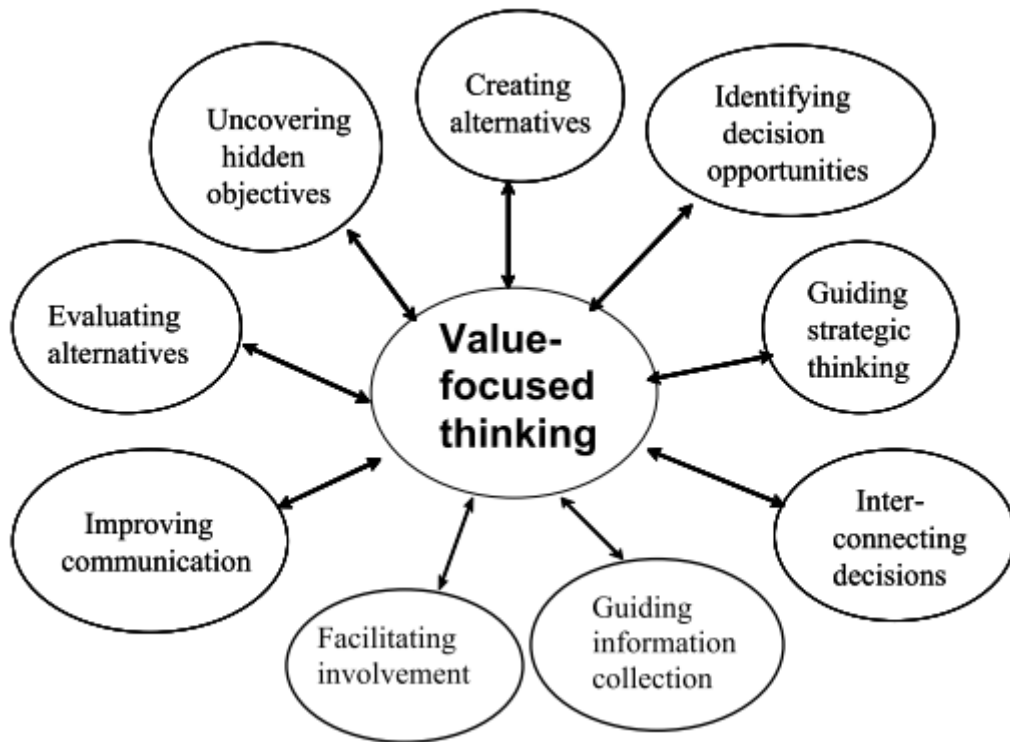
In conclusion, use the values to assess alternatives through the operations-research method called numerous objective decision analysis [15].

VFT is a team sport. The entire team of decision-makers and analysts must accept the philosophy and actively cooperate to create higher-value alternatives for future customers [15].

Value-focused thinking is a way to station a serious resource - solid thinking - to lead to good decisions. Well, decisions come about both because of visions providing by the thinking and because of exact procedures that view decisions through ' value-focused glasses. A shift to this way of thinking around decisions can meaningfully progress in decision making because values guide not only the formation of better replacements but the identification of better decision circumstances [16].

Keeney recognizes nine benefits of value-focused thinking. While most of these benefits are self-explanatory, three are especially relevant to operational analysis. The first is guiding strategic thinking: value-focused thinking can capture the commander's determination for courses of action. The second is evaluating alternatives: multiple objective decision analysis can evaluate alternative courses of

action. The third is creating alternatives: once alternatives are evaluated, they can assess the value gaps (the difference between the ideal value and the best alternative) and focus the exertion to develop better alternatives [15].



**Figure 2.3** Benefits of the Value-Focused Thinking [15]

Keeney's value-focused technique was used to conduct interviews and to found the data into the mandatory network. The main objective of the meeting process was to recognize stakeholders' wishes, concerns, problems, and values relating to ICT security awareness. A conversation document, rather than a questionnaire, was used to get information from the applicants. The discussion document contained six statements or questions and was compiled according to the techniques for the identification of objectives suggested by Keeney [17].

The mechanisms by which value-focused thinking may lead to the generation of more solutions to a problem are yet poorly understood. Both reasoning and motivational mechanisms are possible along with collective mechanisms, by which motivation affects cognition. The requirement of connections between the problem

and a set of values is very similar to the establishment of goals for individuals, groups, or organizations. The requirement of values as a target for solutions, hence, is likely to instigate motivational effects that are similar to those found for goal setting. Goal setting has been reliably found to positively affect the level of motivation at all three levels, compared to a “no goal” condition. When exposed to specific goals, people tend to work harder, be more focused, and more persistent in the face of obstacles. According to the adaptive choices making the perspective on human information processing, higher-level cognitive activities (e.g., thinking, problem-solving) requires effort. The effort involved in problem-solving must be matched with a motivation to spend the effort that is essential for successful completion of the task, i.e., the development of alternative solutions for a problem. Based on this goal-setting effect of value specification, it is likely that more alternatives are developed in a value-based condition related to an alternative based on a problem-solving condition [12].

Therefore, the value-focused instance for addressing choices is different from the standard like the alternative-focused different example in three significant ways. First, significant effort is allocated to make values clear. Logical and systematic concepts are used to qualitatively classify and structure the values suitable for a decision situation. Second, this pronunciation of values in decision circumstances comes before other activities. Third, the articulated values are openly used to classify decision chances and to create alternatives [16]. Value-based selling (VBS) is the operationalization and implementation of VBM at the individual salesperson level. As VBMS emphasizes helping customers to raise revenues, it requires in-depth information about customers’ value-making process and is, therefore, a challenging and time-consuming mission for the seller party. Consequently, a value-based sales method is less satisfactory for commodity offerings of negligible importance to business clients. However, numerous smart services are new offerings that rely on digital technologies to support a customer’s value creation process [18]. According to the adaptive decision-maker perspective on human information processing, higher-level cognitive activities (e.g. thinking, problem-solving) requires effort. The required amount of effort is partly a function of the novelty of the situation and the complexity of the task because the higher the novelty and complexity, the less a



person can rely on mentally stored representations and solutions. The effort involved in problem-solving must be matched with a motivation to spend the effort that is necessary for successful completion of the task, i.e. the development of alternative solutions for a problem. Based on this goal-setting effect of value specification, it is likely that more alternatives are developed in a value-based condition compared to an alternative-based problem-solving condition [12].

According to Rokeach, a value is “a continuing trust that an exact mode of conduct or end-state of presence is personally or socially desirable to a conflicting or opposite mode of conduct or end-state of existence”. Gutman also suggested that “values are special kinds of preferences for modes of conduct or end-states of existence”. To put it simply, values are what one desires to achieve. They are principles used for evaluation by customers. Reynolds and Gutman defined two different kinds of values: terminal and instrumental values. Terminal or “end” values are concerned with preferred states of existence (i.e., happiness, security, or accomplishment), and instrumental or “means” values are related to modes of behavior (i.e., honest, courageous, or broad-minded) which are instrumental in achieving these end-states. The interaction between these “means” and “ends” values is referred to as a value system [19].

### **2.3 Value-Focused Thinking in Education**

Value-focused Thinking is presenting educational and cultural values among students and aims is accomplishing the multi-faceted progress of a human being namely well-informed, physical, mystical, and moral development. The values incorporated in a value-based syllabus may include assistance, responsibility, preference, simplicity, unity, peace, respect, love, tolerance, honesty, self-effacement, and independence. The main purpose of all-inclusive education is to make students meet the hearings of living as well as academics. Multiple studies have stated that value-based education is an all-inclusive approach to students' education, one that delivers comprehensive education of body and mind through ground-breaking approaches and critical educational thinking. Values education helps students finding their place in the world

and build their self-confidence. Values in a school syllabus add a measurement to inspire the holistic progress of the students and benefits to their academic success [20].

The dictionary meanings of the “value”, are in virtuously economic terms, such as “the monetary worth of something: marketable price.” In the background of this book, the researcher uses the broader dictionary definition of “value” as “relative worth, utility, or importance.” This adds complications in requiring VBSE to address less rigorously analyzable situations but enables it to provide help in addressing software engineering decisions involving personal, interpersonal, or ethical considerations [21]. The VFT approach is chosen to answer the research question ‘What are the values of the use of blockchain technology in government in the context of security’ as the approach helps to identify values in terms of security in government’s use of blockchain technology and therefore, identify some essential activities that must occur to address security concerns of users. It is also valuable in bringing out important values in understanding how to maximize user security in blockchain technology [22].

## **2.4 Value-Focused Thinking in Software Engineering**

A resulting value-focused software engineering agenda has emerged, to integrate value considerations into the full range of existing and emerging software engineering principles and practices, and of emerging an overall agenda in which they compatibly reinforce each other. The transition to value-focused software engineering is necessarily evolutionary because it hasn’t all been invented yet. There are no mature packages accessible on the shelf for the execution of software benefits investigation or value-based earned value tracking. As with everything else in information technology, value-focused software engineering is undergoing considerable change [21].

“The ordinary way of thinking about decisions is backward people attention first on finding alternatives rather than on articulating values”. Values are what the team cares about. They should be the pouring force for decision-making. Alternatives are just the means to well achieve the values. Value-focused thinking is not a single method, but instead a method to decision-making that can employ unlike methods [23].

The value-based software engineering plan, defined as the “Accounting for Value in software engineering” sidebar, seeks to integrate value considerations into current and emerging software engineering principles and practices while developing an overall framework in which they compatibly strengthen each other. One area that VBSE addresses—value-based scheduling and control—includes values and practices for encompassing traditional cost, schedule, production scheduling, and control methods that also manage the value distributed to the stakeholders [24].

Numerous studies conducted on value-focused software engineering as shown in Table 2.1:

**Table 2.1** Existing Studies on Value-focused Thinking in Software Engineering

<b>Author/Year</b>	<b>Contribution</b>	<b>Limitation</b>
T.Poleto, T. Clemente, A.de Gusmão et al. (2020) [7]	The framework delivers promising results for ITO decisions. This study exposed that a lack of strategic and essential objectives is a serious issue in making ITO decisions.	-The recommendations of the study is limited to the case study and cannot be generalized. -In addition, applying the method needs attention in determining the standards used for outsourcing IT.

Emily Winter et al. (2019) [25]	In this study, the author uses two principles to advance the study of human values in software production.	-Only identify human Values in software engineering. -only focus on one domain.
Emily Winter and Maria Angela Ferrario (2019) [26]	In this study researchers develop methods and tools to study them in a software engineering context and to build on this understanding to consider how SE research might contribute to more socially responsible software industry.	-only focus human values in software engineering. -Performing activities through Q-methodology.
Paul Ralph et al. (2017) [27]	In this study, the researcher identifies different four types of theory for waste material in software development.	- Grounded Theory does not support statistical generalization. While the proposed taxonomy appears widely applicable, organizations with different software development cultures may experience different waste types.
Barry Boehm (2006) [28]	In this study, the author uses a global road map for realizing the benefits of VBSE.	- Global Road Map for Realizing VBSE Benefits is not related to measuring benefit, its only measures the intermediate outcomes.
Barry Boehm Apurva Jain (2005)	In this study, the researcher Presents an initial “4+1” theory of value-based software	- Apply to a limited number of small e-services applications.

[29]	Software Engineering (VBSE).	<ul style="list-style-type: none"> <li>- Applicable only on few large applications.</li> <li>- Not flexible application.</li> </ul>
Barry Boehm Li Guo Huang (2003) [30]	In this study, researchers include approaches such as participatory design, user Software Engineering, cost estimation, software economics, software investment analysis, and software engineering ethics.	<ul style="list-style-type: none"> <li>- Factors are identified through which control and monitor the approaches of the value-focused software engineering.</li> </ul>
Anne Amels (2002) [31]	In this study, the author compares Stakeholder Approach versus the Shareholder Approach.	<ul style="list-style-type: none"> <li>- focuses on the agency relationship between the actor or the group.</li> <li>- Only focus on stakeholder and shareholder approaches.</li> <li>- limited scope.</li> </ul>

As shown in Table 2.1 there are numerous studies conducted on value-focused software engineering. T.Poleto, T.Clemente, A.de Gusmão, et al [7], performed a study on Integrating value-focused thinking and FITradeoff to support information technology outsourcing decisions. This study provides the framework to delivers promising results for ITO decisions. This study exposed that a lack of strategic and essential objectives is a serious issue in making ITO decisions. It is found that Emily Winter et al. [25][26], Performed two studies on human values in software engineering. In the first study [25] they studied Advancing the Study of Human Values in software engineering This paper argues for the study of human values in Software Engineering (SE) as a highly significant emerging research area with significant societal impact. To advance this research agenda, it offers two key principles: firstly, the significance of values as distinguished from, though linked to, ethics; and secondly, the need for clear theoretical frameworks for Values Study.

Emerging results from the initial study (N=12 participants) are obtainable using a Values Q-Sort tool designed in accordance with these two principles. In second study [26], Emily Winter and Maria Angela Ferrario Studied human values in software engineering. They discussed that there is a pressing need to understand how human values function, develop methods and tools to study them in the context of software engineering and expand on this understanding to consider how SE research could contribute to a more socially responsible software sector. Both studies [25][26], have focused on human values in software engineering. But the proposed work is different in the sense that it is focused on value-focused thinking in software engineering education.

Similarly, a study on value-focused software engineering is conducted by Paul Ralph et al. [27], They defined aims and explain the different types of waste in the production of software. This study is empirical and contains the first taxonomy related to waste. This identifies nine wastes and addresses their causes, underlying tensions, and overall relation to the taxonomy of waste found in Lean software development. But this study focused on Grounded theory does not accept the generalization of statistics. While the classification recommended seems generally applicable, organizations with different software development cultures will experience different types of waste.

Barry Boehm et al conducted three studies on value-focused software engineering [28][29][30]. The first study [28], the spirit of concurrent software and system Software Engineering, focused on its initiatives, contributions, and outcomes at the combined software and information technology (SW/IT) level. In the spirit of parallel software and system Software Engineering. The overall aim is to build and practice fundamental knowledge. In the second study [29], they presented an initial Value-focused Software engineering (VBSE) theory "4+ 1." The engine at the core is the win-win Stakeholder Theory W, which asks "what values are important? "And" What is assured of success? "For the software engineering company in question. The four more theories it draws on are utility theory. In the third study [30], they performed the value-focused approach to software development that includes value considerations with existing and evolving concepts and procedures in software

engineering, while establishing an overarching context in which these approaches compatibly complement one another.

Although all the above-explained studies significantly reported the various works. One of the studies [28], proposed a 4+1 theory for value-focused software engineering while, another researcher [29], represented the overview and research agenda. The researcher in another paper [30], performed a value-focused approach to software development. But proposed work is different from these in the sense that it is focusing on value-focused thinking with an education perspective in software engineering.

Likewise Anne Ameels et al [31]. Reported merit-focused management (VBM). Since VBM is claimed to be changing financial management at the highest level in some of the world's largest companies, this literature review compares the value-focused management approaches of six consultants, viz. Stern Stewart et al. This paper mainly focusing on the value-focused management control process that helps to create value through integration. For this purpose, the author has conducted the research using a sample literature review.

All of the studies discussed in this section were identifying the Values and Value-focused thinking in their respective contexts of software engineering, Development, and management. Although each one of them was having valuable contributions, none of them specifically focused on the VFT in software engineering education which was our point of concern and area of research. This study has reported the gaps in the existing studies in Table 2.2.

Table 2.2 consists of five columns; Reference, Domain of Contribution, VFT, Support to Value-focused Thinking in software engineering education, and Covered VFT practices. Column 'Reference' shows the author's name, year of publication, and type of publication. Column 'Domain of contribution' shows the problem area focused by the studies with its main output. Column 'VFT' shows that whether the study has supported the VFT aspects or not and if yes, then to what extent. Column

‘Support to VFT’ shows that whether the study has supported Value-focused Thinking in Software engineering education or not and if yes, then to what extent. Column ‘Covered VFT Practices’ shows that whether the study has covered all VFT Practices (or not and if yes then to what extent).

## 2.5 Research Gap

**Table 2.2** Gaps in existing studies on Value-focused thinking in Software Engineering

Reference (Authors, Year, Publication Type)	Identified Gaps		
	Value-Focused Thinking	Support to VFT in Software Engineering Education	Covered VFT Practices
T.Poieto, T. Clemente, A.de Gusmão et al. (2020) [7]	This study only integrating value-focused thinking and FITradeoff to support information technology outsourcing decisions.	Nil	Nil
Emily Winter et al. (2019) [25]	This study only identifies human values but is not based on Value-focused thinking.	Nil	Nil
Emily Winter and Maria Angela Ferrario (2019) [26]	This study identifies human values in Software engineering but not especially focuses on the VFT.	Nil	Nil



Paul Ralph et al. (2017) [27]	Provide different four types of theory for waste material in software development but not based on Value-focused thinking.	Nil	Nil
Barry Boehm (2006) [28]	This study provides a global road map for realizing the benefits of VBSE but not based on VFT.	Nil	Nil
Barry Boehm Apurva Jain (2005) [29]	This study is based on the theory of value-based software engineering (VBSE) but not describing the value-focused thinking in software engineering.	Nil	Nil
Barry Boehm Li Guo Huang (2003) [30]	This study identifies factors through which control and monitor the approaches of the value-focused software engineering but not especially based on Value-focused thinking.	Nil	Nil
Anne Ameels (2002) [31]	This study is based on Value-Focused management control processes to create value through integration but not based on value-focused thinking.	Nil	Nil

Found different studies that were focusing on Values, Value-focused in software engineering, and Value-focused in management but not specific in Value-focused thinking in software engineering education.

As shown in Table 2.2, T. Poletto, T. Clemente, A. de Gusmão, et al [7], come up with an Integrating value-focused thinking and FITradeoff to support information technology outsourcing decisions. This study provides the framework to deliver promising results for ITO decisions. This study exposed that a lack of strategic and essential objectives is a serious issue in making ITO decisions. Its scope was too general and did not give details at VFT in software engineering education. The study ignored the aspects of VFT in software engineering education. Besides this due to its general scope and dimensions, this study also lacked to specifically focus on VFT in software engineering education and its practices, which is our point of concern.

Emily Winter et al [25] came up with an Advancing the Study of Human Values in software engineering. Although this study was the first step towards Advancing human values in software engineering, its scope was too general and did not give details at VFT. The study ignored the aspects of VFT. Besides this due to its general scope and dimensions, this study also lacked to specifically focus on VFT and its practices, which is our point of concern. The same case with the studies of Emily Winter and Maria Angela Ferrario [26] that they significantly supported the VFT and they do not support VFT in software engineering in their respective research domains but none of them have specifically focused on VFT in software engineering education. Although all the existing studies have significance reported the importance of value-focused thinking in software engineering. However, none of them focus on value-focused thinking integration with software engineering education.

From the above-mentioned discussion, this study recognized that there were existing studies that reported values, value-focused software engineering, and value-focused management in the form of software engineering and management, but most of them were very general and lacked the in-depth understanding of Value-focused thinking in software engineering education. Besides this, none of the declared studies in Table

2.2 were concentrating on VFT practices and Value-focused thinking in software engineering education, moderately only focal point of their work was towards a Values focused thinking in software engineering and value-focused in management.

## **2.6 Summary**

This chapter described the concept of VFT in software engineering education, as well as the Practices of Value, focused thinking in software engineering education. It further explains the concept of VFT in software engineering education. The chapter reports the existing studies that support VFT in software engineering education and showed some of the studies that report VFT directly or indirectly. Furthermore, the gaps in the existing studies are highlighted and described in this chapter. The methodology for conducting this research is discussed in Chapter 3.

## **CHAPTER 3**

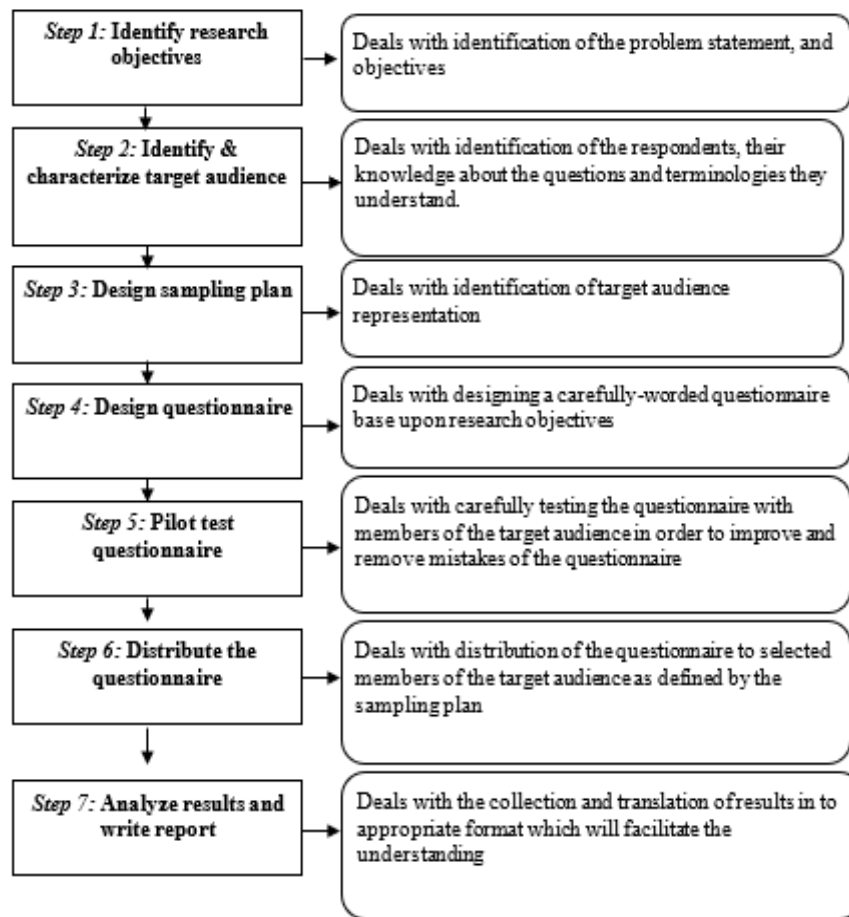
### **METHODOLOGY**

#### **3.1 Introduction**

Chapter 2, stated the Existing studies that presented the gap in the field of Value-focused Thinking in software engineering education, specifically for identifying the Practices of VFT that affect VFT practices in software engineering education. In this Chapter, the set of methodologies used to follow the research are reported and discussed.

#### **3.2 Survey Methodology**

A survey was directed by following the guidelines of Kasunic [32] issued by the Software Engineering Institute (SEI). This followed his work as it is the most common and usually used handbook for conducting an effective survey in the field of software engineering. Figure 3.1 shows the steps for survey conduction.



**Figure 3.1** shows the steps for survey conduction [32]

### 3.2.1 Research Objective of the Study

Objective 1: To identify awareness about value-focused thinking to students and faculty.

Objective 2: To identify the practices which make the value base thinking in software engineering education.

Objective 3: To generate an approach for diffusing value-focused thinking in software engineering education.

### 3.2.2 Target Audience

This study focused on those universities which offering software engineering degree. The target audience for this research was the faculty and students of the software engineering department. For appropriate identification of the target audience, this focused on certain questions adapted from the work of Kasunic [32]. Table 3.1 shows the set of questions, this study focused on while identifying and characterizing our target audience. The detail of the faculty and student audience is attached in Appendix B and C.

**Table 3.1** Questions to identify and characterize target audience, adapted from work of Kasunic [32]

<b>Questions for Identifying and Characterizing the Target Audience</b>
<ol style="list-style-type: none"><li>1. How many people are in the population we are studying?</li><li>2. What are their jobs and responsibilities?</li><li>3. What is the most common education level?</li><li>4. Do we anticipate that they would have difficulty with using a questionnaire that is:<ul style="list-style-type: none"><li>– mailed to them?</li><li>– completed using a computer via the internet?</li><li>– handed to them?</li></ul></li><li>5. What can we assume about their knowledge of the domain we are studying in the survey?</li><li>6. How much of their time can we assume they will spend completing the questionnaire?</li></ol>

### 3.2.3 Sampling

A sample is the subset of the total population, having characteristics of the population. In this study, the questionnaire was sent to those universities which offering the software engineering degree in Pakistan. The detail of the selected

educational institute is attached in Appendix A and the detail of the selected faculty and student audience is attached in Appendix B and C (list of faculty and student audience). The criterion for a short listing of universities was that they must be doing a degree in software engineering. This study used a purposive sampling strategy because our target audience was a specific group and accessing them was difficult. A contact person from the universities was selected so that the questionnaire could be forwarded to the relevant faculty and students and accurate feedback could be gathered.

### 3.2.4 Questionnaire Development

A questionnaire was designed to; 1) identify awareness about value-focused thinking to students and faculty, 2) identify the practices which make the value base thinking in software engineering education, 3) generate an approach for diffusing value-focused thinking in software engineering education. It was made possible by addressing the questions adapted from the work of Kasunic [32]. Table 3.2 shows the questions that considered while designing and developing the questionnaire. The questionnaire is attached in Appendix D of the thesis.

**Table 3.2** Questions for designing the questionnaire, adapted from work of Kasunic [32]

<b>Questions for Designing a Questionnaire</b>
1. How will the survey be mediated (e.g., via paper, email soft copy, Web)?
2. How long should the questionnaire be?
3. How should the questionnaire be structured and organized?
4. What page design and formatting will be most effective?

The survey was divided into four main sections. The first section of the survey was aimed to identify the respondent's personal information, their current position in the

institute, VFT was working on, their education level, and overall experience in software engineering.

The second section of the questionnaire asked the respondents about awareness of value-focused thinking in software engineering education. There were two parts of this section 1) level regarding value-focused thinking awareness, 2) measure the awareness of value-focused thinking in software engineering education. For first part of this section, this study used the four-point Likert scale; (Basic = 0.25, intermediate = 0.5, Advance = 0.75, Expert = 1) [33]. Similarly, for the second part of this section (awareness of VFT in Software engineering education), this used the five-point Likert scale; Strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1.

The third section of the questionnaire asked about value-focused thinking practices in software engineering education. There were three parts of this section 1) which practice is useful in software engineering education, 2) which practice is more valuable, 3) which practice is most useful to reduce waste material for you while you would be developing a system. For first part of this section, this study used the five-point Likert scale; strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly disagree = 1. For the second and third part of this section, this study used the three-point Likert scale; (Guiding strategic thinking = 0.5, Evaluating alternatives = 0.75, Creating alternatives = 1) [33].

The fourth section of the questionnaire asked about diffusing the value-focused thinking practices in software engineering education. There was two part of this section 1) way to diffuse the practices in software engineering education, 2) which action can take to diffuse value-focused thinking practices in software engineering education. For first part of this section, this study used the five-point Likert scale; strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly disagree = 1. For the second part of this section, we used the four-point Likert scale; (Make part of study = 0.25, Apply in every class project = 0.5, Conduct workshop = 0.75, Apply in final Project = 1) [33].



### **3.2.5 Pilot Test**

In pilot testing to validate the questionnaire by applying 4 steps of validation.

1. Establish face validity
2. Pilot test
3. Clean data set
4. Revise questionnaire.

#### **3.2.5.1 Establish face validity**

The Establish faced validity was a two-step process survey which has involved two different groups of people. The first group of people was an expert who has deep knowledge about this study who can evaluate the question successfully. The second group of people was an expert on question construction, ensuring that the survey does not contain common errors such as leading, confusing, or double-barreled questions.

#### **3.2.5.2 Pilot test**

The questionnaire development process included a pilot study, which was used for modifications and eliminations related to the information and questions mentioned in the questionnaire until the final questionnaire was designed. Conducted the pilot study for validation and improvement of the questionnaire, in terms of the statements, wordings, sequencing along with the potential interests of the participants. The questionnaire was forwarded to 5 members of the target audience. Their comments were generally related to the wordings of the questions and statements. Some of the respondents commented that they faced difficulty in understanding the VFT practices. Similarly, some have shown concerns related to question descriptions. Based on their comments and suggestions the questionnaire

was modified and improved. The questions and statements were corrected and improved for their clear and accurate understandings. The final version of the questionnaire is attached in Appendix D.

### **3.2.5.3 Clean Data Set**

After collection of data from respondent's data enter into the excel sheet. Check the respondent carefully fill the questionnaire or not by comparing the consistency of the phrased negatively question with phrased positively question. After comparing the results, the question which has a similar answer is included rest of the data was removed.

### **3.2.5.4 Revise questionnaire**

This is the final stage of the questionnaire development process. After collection of data from PCA and CA. Based on their comments and suggestions the questionnaire was modified and improved. The questions and statements were corrected and improved for their clear and accurate understandings. The final version of the questionnaire is attached in Appendix D.

### **3.2.6 Questionnaire distribution and data collection**

After completing the pilot study, the survey package was sent to the target audience. The survey package comprised of an invitation email and questionnaire. This study used an online survey to get data from multiple respondents of the educational institute. Make sure that the respondents have working experience in VFT. The detail of the distribution of respondent's responses are reported in Chapter 5; Sections 5.1 and 5.2. The sample of the invitation letter and questionnaire is attached in Appendix D.

### **3.2.7 Analyze Results and Write a Report**

The data analysis part of our research was consisting of quantitative analysis. For our data analysis, this study has performed statistical analysis to investigate the particular awareness, practices, and how to diffuse these practices of Value-focused thinking which can be identified in our research. This study decomposed the data gathered from educational institutions into three parts; 1) responses related to awareness of value-focused thinking in software engineering education, 2) responses related to the practices of value-focused thinking in software engineering education, and 3) responses related to how to diffused these practices. Applying the formula for analyzing the results (like arithmetic mean and average), after the collections of the results can right report based on results.

### **3.3 Chapter Summary**

This chapter described the research design used for data collection and data analysis with the set of methodologies and techniques to achieve our research objectives. This chapter has reported the steps to conduct the survey methodology with a detailed description of the set of activities that were performed to gather the institution's responses. This chapter also reported the evaluation methodology that was based on the experiment. The steps and procedures to experiment evaluating awareness, practices, and how to diffuse practices are detailed in this chapter. The implementation of the survey methodology and its results are reported in Chapter 4.

## **CHAPTER 4**

### **ANALYSIS**

#### **4.1 Introduction**

Chapter 3 illustrated the methodologies, techniques, and steps to achieve our research objectives. The list of practices of value-focused thinking was forwarded to the educational institute for investigating the institutions respondent's perceptions on VFT awareness, perceptions on practices of value-focused thinking in software engineering education, and investigating how to diffuse these practices. This chapter illustrates the results of the survey.

#### **4.2 Survey Conduction**

A survey was directed by following the guidelines of Kasunic [32]. The information about survey steps, objectives, choice of the target audience to conduct the survey is reported in Chapter 3. The research area of this study precisely focused on value-focused thinking in software engineering education, so the target population of our study was the educational institution of Pakistan that were working in software engineering degrees. The questionnaire was sent to the target institution in early November 2020 (A list of the institutions is attached in Appendix A). The survey comprised four main sections. Section I was designed to get the personal information of the respondent.

Section II of the questionnaire to get the awareness of respondents regarding value-focused thinking in software engineering education. The respondents were asked to give opinions about the awareness of value-focused thinking in software engineering education and give responses regarding the level of awareness of value-focused thinking in software engineering education. The list of faculty respondents is attached in Appendix B. The list of student respondents is attached in Appendix C. Section III was designed to get an opinion about the practices of value-focused thinking in software engineering education. Section IV was designed to get an opinion of how to diffuse these practices in software engineering education. The questionnaire is attached in Appendix D.

Of the 350 emails sent to the contact persons of the educational institute including faculty and student (270 emails sent to students and 80 sent to faculty members of the software engineering department), a total of 25 faculty members and 70 students responded and fill that the questionnaire. The follow-up emails were sent to the non-respondents of the 55 faculty members and 150 students about one month after the first email. This process continuously runs and kept on getting responses slowly. After 2 months and 10 days, we got 30 responses from faculty and 100 from students, which were still very low in percentage.

To increase the response rate, this study planned to send the questionnaire through social media (WhatsApp and messenger). Managed to get the WhatsApp number and messenger id of respondents of the different institutions. This study conveyed our survey objective to them. After they agreed, forwarded the survey by WhatsApp and Messenger and managed to get 20 more responses from faculty and 80 responses from students. Waited for responses till the start of January 2021 and got 10 more responses from faculty and 20 responses from students within this duration. Finally, by combining all the responses, a total of (80 faculty and 270 students) responses were received. Complete responses (60 faculty and 200 students) among the total responses that were used in our data analysis.

The data collected from the respondents were decomposed into two parts based upon their receiving dates. The respondents from the first email till sending the online questionnaire were considered as early respondents and the responses got from the remainder of email, WhatsApp, and messenger were considered as late respondents. To examine the response biases, performed the ‘Response Biasness’ test. To do so ‘An Independent Sample t-test’ was performed on the responses gathered from these two groups (early and late respondents). This study performed the analysis for each Practice of VFT in software engineering education.

### 4.3 Descriptive Statistics of Faculty Respondents

The first part of the questionnaire was to investigate the respondent’s personal information. The respondents were asked about their current position in the university. Table 4.1 shows the circulation of the respondents based on their position in the university. Through survey found that 24% of the respondents were working as Lecturer in the software engineering department, the respondents working as an Associate professor were 76% each respondent were working in the software engineering department.

**Table 4.1** Distribution of respondents, based on positions in university

<b>Position</b>	<b>Frequency</b>	<b>Percent</b>
Lecturer	12	24%
Associate professor	38	76%
Total	50	100%

#### 4.4 Descriptive Statistics of Student Respondents

The first part of the questionnaire was to examine the respondent's personal information. The respondents were asked about their current semester in the institution. Table 4.2 shows the circulation of respondents based on their semester in the university. Through survey found that 21.5% of the respondents were students of the 4<sup>th</sup> semester, 26.5% of the respondents were students of the 5<sup>th</sup> semester, 20.5% of the respondents were students of the 6<sup>th</sup> semester, 15.5% of the respondents were students of the 7<sup>th</sup> semester and 26% of the respondents were students of the 8<sup>th</sup> semester, each respondent was a student in the software engineering department.

**Table 4.2** Distribution of respondents, based on the semester in university

<b>Position</b>	<b>Frequency</b>	<b>Percent</b>
4 <sup>th</sup>	43	21.5%
5 <sup>th</sup>	53	26.5%
6 <sup>th</sup>	41	20.5%
7 <sup>th</sup>	31	15.5%
8 <sup>th</sup>	32	16%
Total	200	100%

#### 4.5 Result Analysis Related to Awareness of VFT in Software Engineering Education.

This section reports the results for the perceived awareness and opinions of the respondent on value-focused thinking in software engineering education. This section consists of two parts. The first part consists of faculty responses about the perceived awareness of value-focused thinking in software engineering education

and the second part consist of student responses about perceived awareness of value-focused thinking in software engineering education.

#### 4.5.1 Faculty Perception on Awareness of VFT in Software Engineering Education.

The purpose of directing this part of the survey was to monitor the perceived awareness of faculty about value-focused thinking in software engineering education. This section of the questionnaire consists of two parts. In first part a four-point Likert scale ranging from 0.25 to 1 (Basic=0.25, intermediate=0.5, advance=0.75, expert=1) [33]. In the second part, a five-point Likert scale ranging from 1 to 5 (Strongly Agree- 5, Agree - 4, Neutral - 3, Disagree- 2, Strongly Disagree – 1) was provided (explained in Chapter 3). The mean perceived awareness of value-focused thinking was calculated in this section. The detailed value of mean is attached in Appendix E. The results of perceived awareness of value-focused thinking according to faculty in software engineering education are attached in Appendix G. Figure 4.1 shows the faculty expertise level of perceived awareness about value-focused thinking in software engineering education and Figure 4.2 show the opinion of faculty about awareness of value-focused thinking in software engineering education.

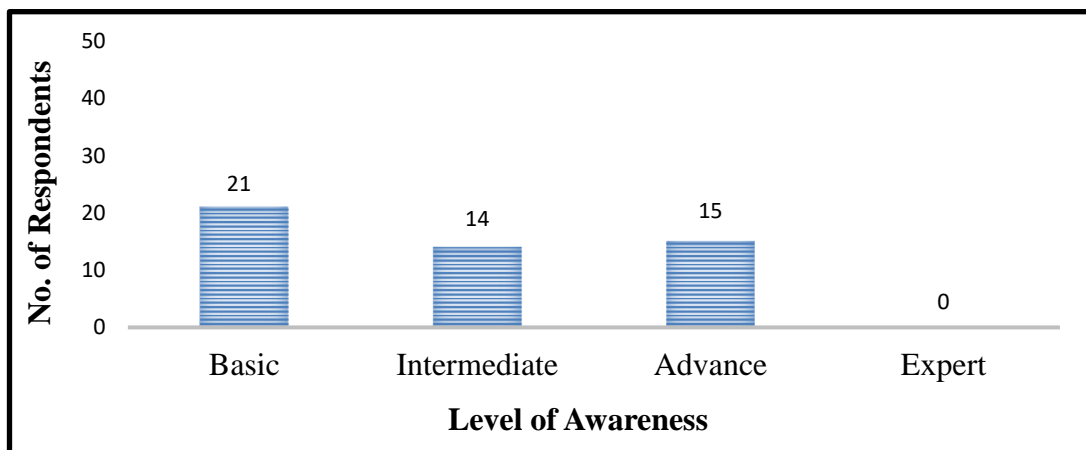
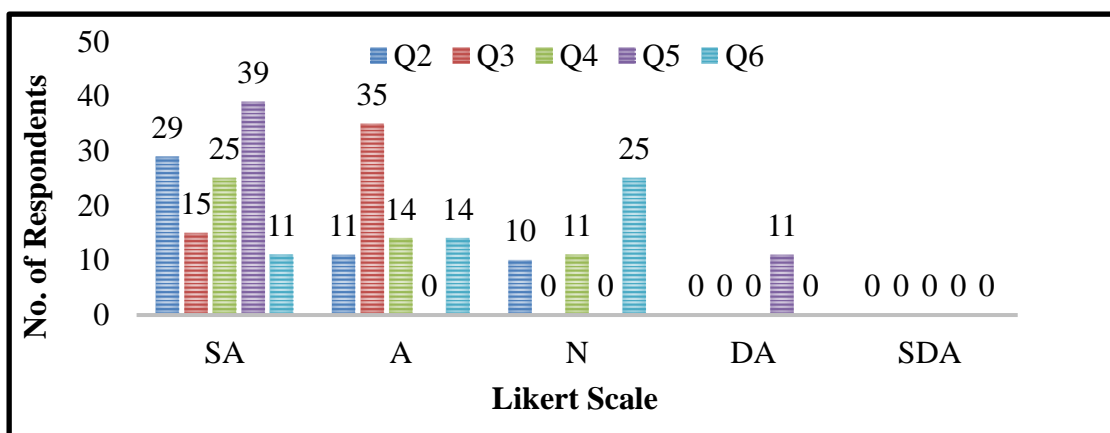


Figure 4.1 Faculty Level of awareness regarding VFT



Figure 4.1 Level of awareness regarding VFT, shows the number of people according to the level of expertise. In this section, the figure shows that 21 out of 50 faculty members which have a basic level of understanding about value-focused thing in software engineering education, 14 out of 50 faculty members which have an intermediate level of value understanding focused thing in software engineering education, 15 out of 50 faculty members which have an advance level of understanding about value-focused thing in software engineering education and no one is the expert level of understanding of value-focused thinking in software engineering education.



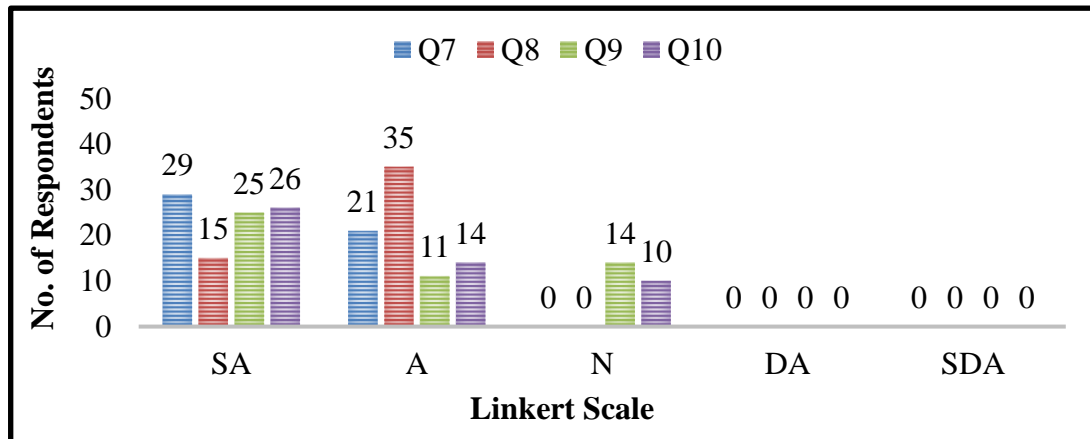
**Figure 4.2** opinions of faculty about awareness of VFT in software engineering education

Figure 4.2 shows the opinions of faculty members about awareness of VFT in software engineering education. In this section figure show 5 different questions. For Q2 figure show that 29 out of 50 faculty members strongly agree with Q2, 11 out of 50 faculty members agree with Q2, 10 out of 50 faculty members neutral with Q2, and no one out of 50 faculty members disagrees with Q2 and similarly, no one out of 50 faculty members strongly disagrees with Q2. For Q3 figure show that 15 out of 50 faculty members strongly agree with Q3, 35 out of 50 faculty members agree with Q3, zero out of 50 faculty members Neutral, and zero out of 50 faculty members disagree with Q3 and similarly, no one out of 50 faculty members strongly disagrees with Q3. similarly for Q4 figure show that 25 out of 50 faculty members strongly agree with Q4, 14 out of 50 faculty members agree with Q4, 11 out of 50 faculty members neutral with Q4, and zero out of 50 faculty member disagree with Q4 and

similarly zero out of 50 faculty member strongly disagree with Q4. For Q5 figure show that 39 out of 50 faculty members strongly agree with Q5, zero out of 50 faculty members agree with Q5, zero out of 50 faculty members neutral, and 11 out of 50 faculty members disagree with Q5 and no one out of 50 faculty members strongly disagrees with Q5. Similarly, For Q6 figure show that 11 out of 50 faculty members strongly agree with Q6, 14 out of 50 faculty members agree with Q6, 25 out of 50 faculty members neutral with Q6, and no one out of 50 faculty member disagrees with Q6 and similarly zero out of 50 faculty members strongly disagree with Q6.

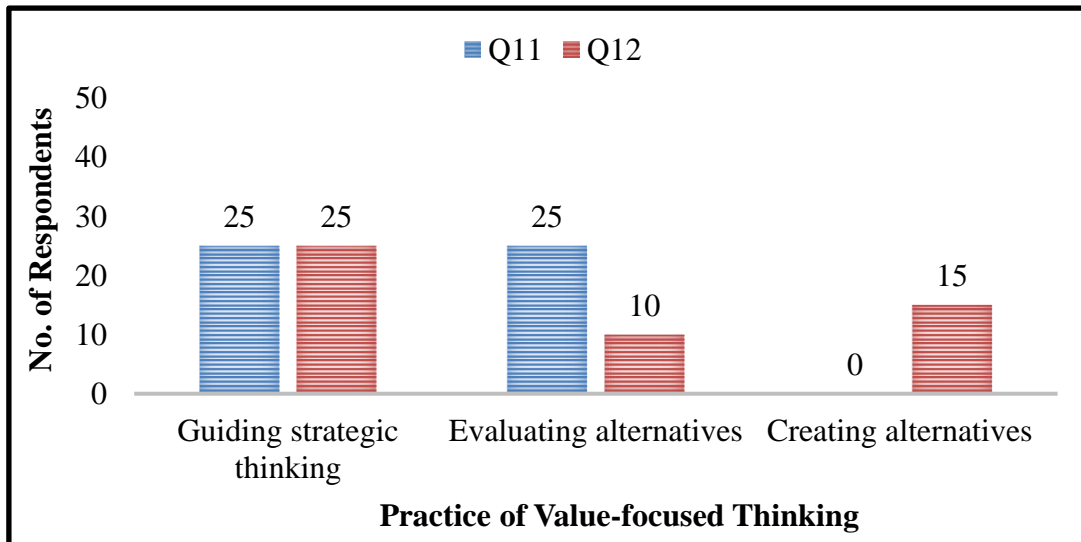
#### **4.5.2 Faculty Perception on Practices of VFT in Software Engineering Education.**

The purpose of directing this part of the survey was to monitor the perception of faculty members on practices of value-focused thinking in software engineering education. This section of the questionnaire consists of two parts. In the first part a five-point Likert scale ranging from 1 to 5 (Strongly Agree- 5, Agree - 4, Neutral - 3, Disagree- 2, Strongly Disagree – 1). In second part a three-point Likert scale ranging from 0.5 to 1 (guiding Strategic thinking =0.5, Evaluating alternatives = 0.75, Creating alternatives = 1) [33] was provided (explained in Chapter 3). The mean perception of practices of value-focused thinking was calculated in this section. The mean perception on practices of value-focused thinking in software engineering education is detailed in Appendix E. The results of faculty perception on practices of value focused thinking are attached in the Appendix G. Figure 4.3 shows the faculty opinions on the practices of value-focused thinking in software engineering education and Figure 4.4 shows the opinion of faculty on practices which is more valuable in software engineering education.



**Figure 4.3** Perception of faculty on practices of VFT

Figure 4.3 shows the perception of faculty members on practices of VFT in software engineering education. In this section figure show 4 different questions. For Q7 figure show that 29 out of 50 faculty members strongly agree with Q7, 21 out of 50 faculty members agree with Q7, no one out of 50 faculty members neutral with Q7, and no one out of 50 faculty members disagrees with Q7 and similarly, no one out of 50 faculty members strongly disagrees with Q7. For Q8 figure show that 15 out of 50 faculty members strongly agree with Q8, 35 out of 50 faculty members agree with Q8, no one out of 50 faculty members Neutral with Q8, and no one out of 50 faculty members disagrees with Q8 and similarly zero out of 50 faculty members strongly disagree with Q8. Similarly for Q9 figure show that 25 out of 50 faculty members strongly agree with Q9, 11 out of 50 faculty members agree with Q9, 14 out of 50 faculty members neutral with Q9, and no one out of 50 faculty member disagrees with Q9 and similarly no one out of 50 faculty member strongly disagrees with Q9. For Q10 figure show that 26 out of 50 faculty members strongly agree with Q10, 14 out of 50 faculty members agree with Q10, 10 out of 50 faculty members neutral with Q10, and no one out of 50 faculty members disagrees with Q10, and no one out of 50 faculty members strongly disagrees with Q10.



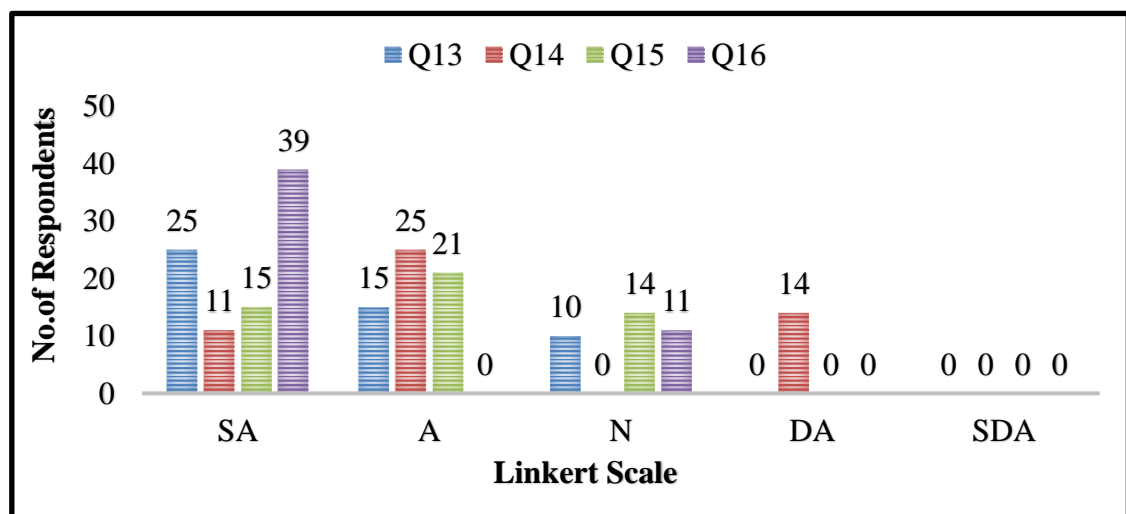
**Figure 4.4** Perception of faculty on valuable practices of VFT

Figure 4.4 shows that the comparison between the practices of value-focused thinking in software engineering education shows that which practice is more valuable. Figure 4.3 consists of 2 questions. In question 11 ask about which practice is more valuable 25 faculty members out of 50 say that guiding strategic is a more valuable practice, 25 faculty members out of 50 say that evaluating alternatives is a more valuable practice in software engineering education and no one say that creating alternatives is more valuable in software engineering education. Similarly, in question 12 ask about which practice is more useful for reducing waste material during developing a system. 25 out of 50 say that guiding strategic is more useful practice for reducing waste material during development system, 10 out of 50 say that guiding strategic is more useful practice for reducing waste material during development system and 15 out of 50 say that guiding strategic is more useful practice for reducing waste material during development system.

#### **4.5.3 Faculty Perception on how to Diffuse the Practices of VFT in Software Engineering Education.**

The purpose of directing this part of the survey was to monitor the perception of faculty members on how to diffuse the practices of value-focused thinking in

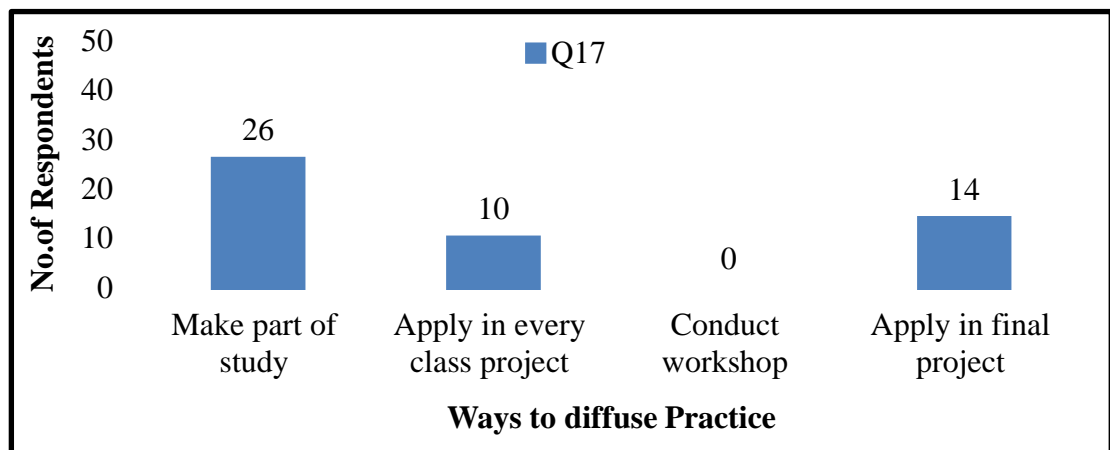
software engineering education. This section of the questionnaire consists of two parts. In the first part a five-point Likert scale ranging from 1 to 5 (Strongly Agree- 5, Agree - 4, Neutral - 3, Disagree- 2, Strongly Disagree – 1). In the second part, a four-point Likert scale ranging from 0.25 to 1 (Make part of study =0.25, Apply in every class project = 0.5, conduct workshop = 0.75, Apply in final year project =1) [33] was provided (explained in Chapter 3). The mean perception on how to diffuse the practices of value-focused thinking was calculated in this section the detailed value of mean is attached in Appendix E. The results of faculty perception on how to diffuse the practices of value-focused thinking in software engineering education are detailed in Appendix G. Figure 4.5 shows the faculty members opinions on how to diffuse the practices of value-focused thinking in software engineering education and Figure 4.6 show the opinion of faculty members on the practices diffusion methods and which method is more suitable to diffuse the practices of value-focused thinking in software engineering education.



**Figure 4.5** opinion of faculty on diffusing practices of VFT in Software engineering education

Figure 4.5 shows the perception of faculty members on how to diffuse the practices of VFT in software engineering education. In this section figure show 4 different questions. For Q13 figure show that 25 out of 50 faculty members strongly agree with Q13, 15 out of 50 faculty members agree with Q13, 10 out of 50 faculty members neutral with Q13, and no one out of 50 faculty members disagrees with Q13 and similarly, no one out of 50 faculty members strongly disagrees with Q13.

For Q14 figure show that 11 out of 50 faculty members strongly agree with Q14, 25 out of 50 faculty members agree with Q14, no one out of 50 faculty members Neutral with Q14, and 14 out of 50 faculty members disagree with Q14 and similarly zero out of 50 faculty members strongly disagree with Q14. Similarly for Q15 figure show that 15 out of 50 faculty members strongly agree with Q15, 21 out of 50 faculty members agree with Q15, 14 out of 50 faculty members neutral with Q15, and no one out of 50 faculty member disagrees with Q15 and similarly, no one out of 50 faculty member strongly disagrees with Q15. For Q16 figure show that 39 out of 50 faculty members strongly agree with Q16, no one out of 50 faculty members agree with Q16, 11 out of 50 faculty members neutral with Q16, and no one out of 50 faculty members disagrees with Q16, and no one out of 50 faculty members strongly disagrees with Q16.

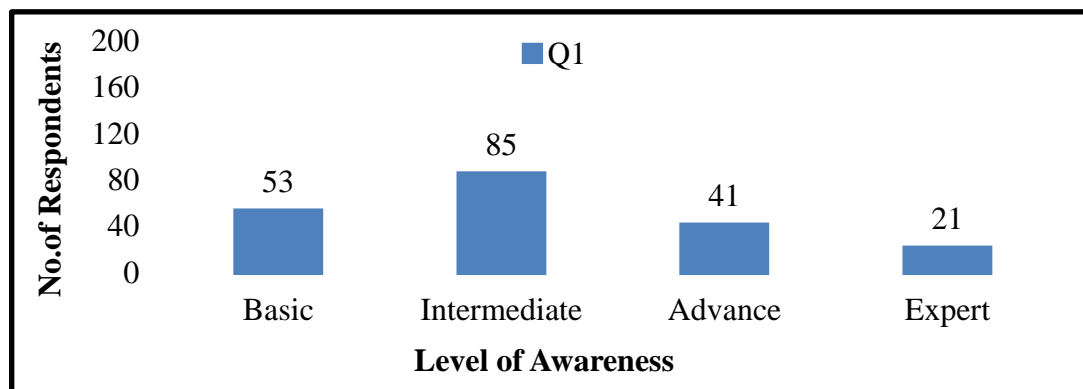


**Figure 4.6** According to faculty the ways how to diffuse practices

Figure 4.6 shows the comparison between the ways to diffuse the practices of value-focused thinking in software engineering education. In this section figure show that 26 out of 50 faculty members say that practices of value-focused thinking make a part of the study, 10 out of 50 faculty members say that practices of value-focused thinking apply in every class project, no one out of 50 members say that practices of value-focused diffuse through conduct workshop and 14 out of 50 faculty members say that practices of value-focused thinking apply in the final project.

#### 4.5.4 Student Perception on Awareness of VFT in Software Engineering Education.

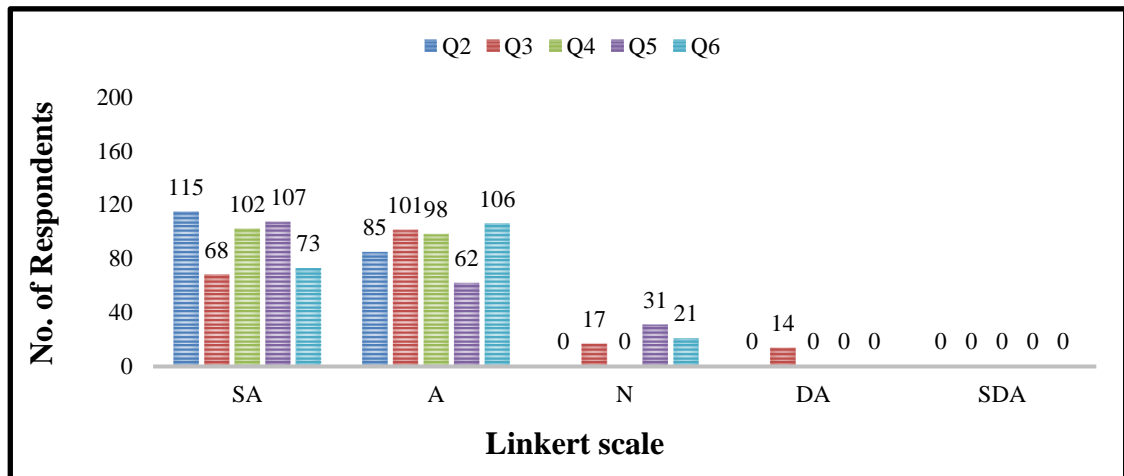
The purpose of directing this part of the survey was to monitor the perceived awareness of students about value-focused thinking in software engineering education. This section of the questionnaire consists of two parts. In first part a four-point Likert scale ranging from 0.25 to 1 (Basic=0.25, intermediate=0.5, advance=0.75, expert=1) [33]. In the second part, a five-point Likert scale ranging from 1 to 5 (Strongly Agree- 5, Agree - 4, Neutral - 3, Disagree- 2, Strongly Disagree – 1) was provided (explained in Chapter 3). The mean perceived awareness of value-focused thinking was calculated in this section. The detailed value of mean is attached in Appendix F. The results of the student perceived awareness of value-focused thinking in software engineering education are attached in Appendix H. Figure 4.7 shows the students' expertise level of perceived awareness about value-focused thinking in software engineering education and Figure 4.8 show the opinion of student about awareness of value-focused thinking in software engineering education.



**Figure 4.7** Student's level of awareness regarding VFT

Figure 4.7 Level of awareness regarding VFT, shows the number of students according to the level of expertise. In this section, the figure shows that 53 out of 200 students who have a basic level of understanding about value-focused thing in software engineering education, 85 out of 200 students which have an intermediate level of understanding about value-focused thing in software engineering education,

41 out of 200 students which have an advance level of understanding about value-focused thing in Software engineering education and 21 out of 200 students was the expert level of understanding of value-focused thinking in software engineering education.



**Figure 4.8** opinions of students about awareness of VFT in Software engineering education

Figure 4.8 shows the opinions of students about awareness of VFT in software engineering education. In this section figure show 5 different questions. For Q2 figure show that 115 out of 200 students strongly agree with Q2, 85 out of 200 students agree with Q2, no one out of 200 students neutral with Q2, and no one out of 200 students disagrees with Q2 and similarly, no one out of 200 students strongly disagrees with Q2. For Q3 figure show that 68 out of 200 students strongly agree with Q3, 101 out of 200 students agree with Q3, 17 out of 200 students Neutral with Q3, 14 out of 200 students disagree with Q3 and similarly, no one out of 200 students strongly disagrees with Q3.similarly for Q4 figure show that 102 out of 200 students strongly agree with Q4, 98 out of 200 students agree with Q4, zero out of 200 students neutral, and zero out of 200 students disagree with Q4 and similarly zero out of 200 students strongly disagree with Q4. For Q5 figure show that 107 out of 200 students strongly agree with Q5, 62 out of 200 students agree with Q5, 31 out of 200 students neutral with Q5, and zero out of 200 students disagree with Q5 and no one out of 200 students strongly disagrees with Q5. Similarly, For Q6 figure show



that 73 out of 200 students strongly agree with Q6, 106 out of 200 students agree with Q6, 21 out of 200 students neutral with Q6, and no one out of 200 students disagrees with Q6, and similarly zero out of 200 students strongly disagree with Q6.

#### 4.5.5 Student Perception on Practices of VFT in Software Engineering Education.

The purpose of directing this part of the survey was to monitor the perception of students on practices of value-focused thinking in software engineering education. This section of the questionnaire consists of two parts. In the first part a five-point Likert scale ranging from 1 to 5 (Strongly Agree- 5, Agree - 4, Neutral - 3, Disagree- 2, Strongly Disagree – 1). In second part a three-point Likert scale ranging from 0.5 to 1 (guiding Strategic thinking =0.5, Evaluating alternatives = 0.75, Creating alternatives = 1) [33] was provided (explained in Chapter 3). The mean perception of practices of value-focused thinking was calculated in this section. The detailed value of mean is attached in Appendix F. The results of student perception on practices of value-focused thinking in software engineering education are attached in Appendix H. Figure 4.9 shows the students opinions on the practices of value-focused thinking in software engineering education and Figure 4.10 show the opinion of students on practices which is more valuable in software engineering education.

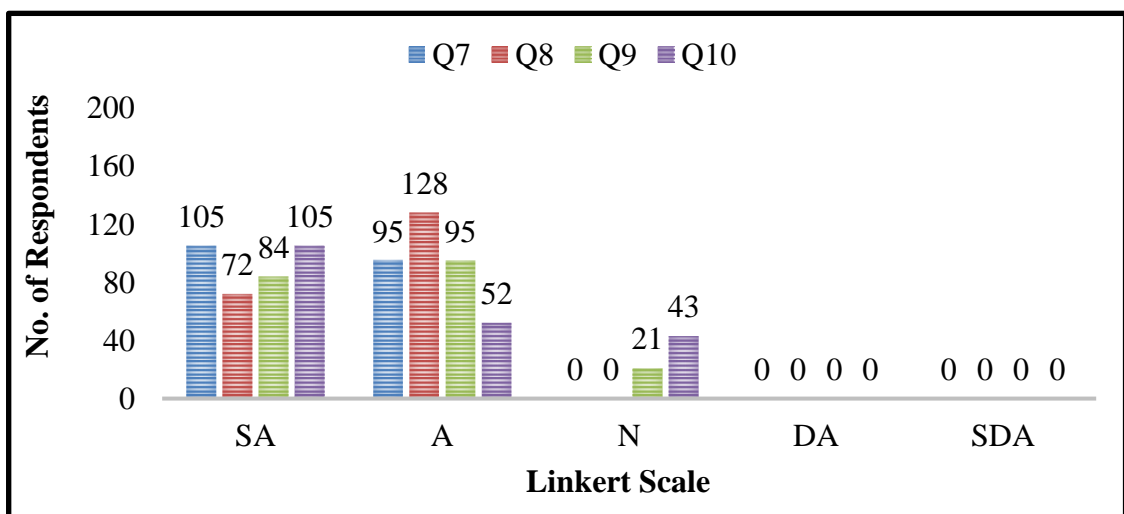
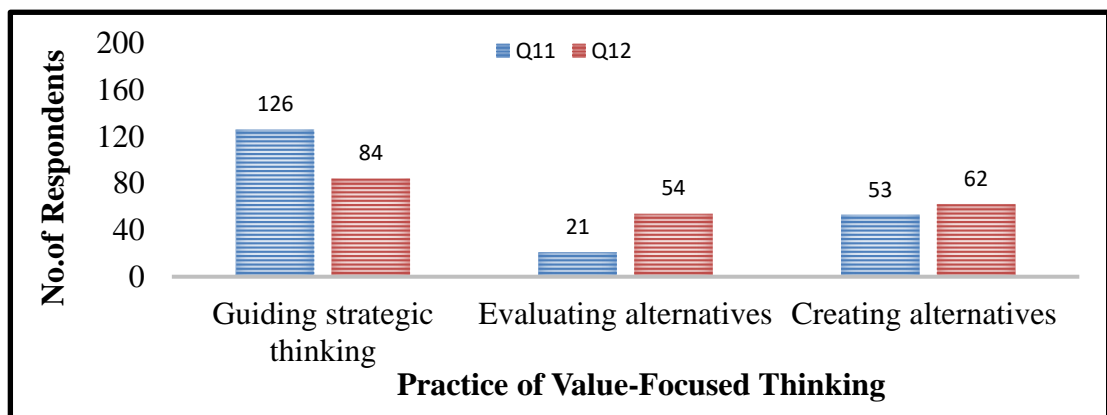


Figure 4.9 Perception of students on practices of VFT

Figure 4.9 shows the perception of students on practices of VFT in software engineering education. In this section figure show 4 different questions. For Q7 figure show that 105 out of 200 students strongly agree with Q7, 95 out of 200 students agree with Q7, no one out of 200 students neutral with Q7, and no one out of 200 students disagrees with Q7 and similarly, no one out of 200 students strongly disagrees with Q7. For Q8 figure show that 72 out of 200 students strongly agree with Q8, 128 out of 200 students agree with Q8, no one out of 200 students Neutral with Q8, and no one out of 200 students disagrees with Q8, and similarly zero out of 200 students strongly disagree with Q8. Similarly for Q9 figure show that 84 out of 200 students strongly agree with Q9, 95 out of 200 students agree with Q9, 21 out of 200 students neutral with Q9, and no one out of 200 students disagrees with Q9 and similarly no one out of 200 students strongly disagrees with Q9. For Q10 figure show that 105 out of 200 students strongly agree with Q10, 52 out of 200 students agree with Q10, 43 out of 200 students neutral with Q10, and no one out of 200 students disagrees with Q10, and no one out of 200 students strongly disagrees with Q10.



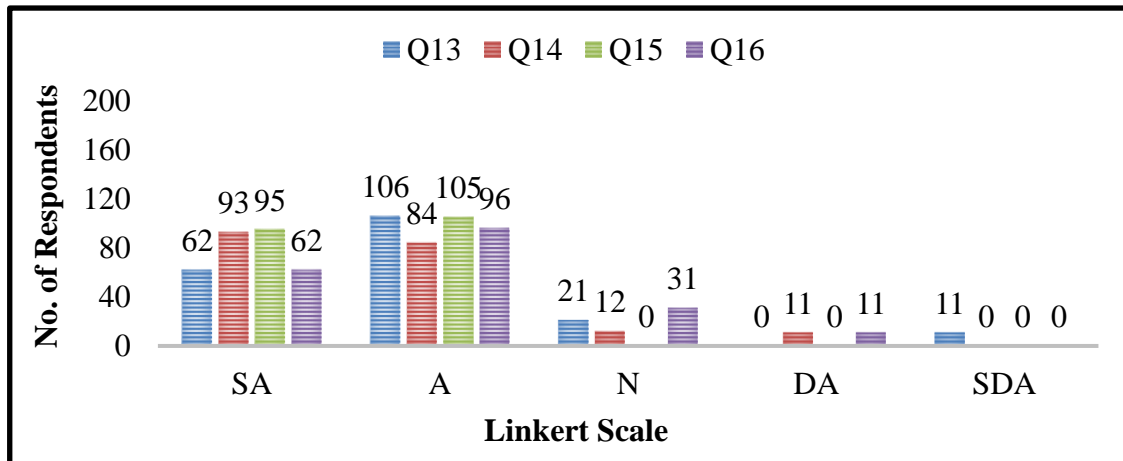
**Figure 4.10** According to student the valuable practice of VFT

Figure 4.10 shows that the comparison between the practices of value-focused thinking in software engineering education shows that which practice is more valuable. Figure 4.3 consists of 2 questions. In question 11 ask about which practice is more valuable 126 students out of 200 say that guiding strategic is a more valuable practice, 21 students out of 200 say that evaluating alternatives is a more valuable practice in software engineering education, and 53 out of 200 students say that creating alternatives is more valuable in software engineering education. Similarly, in

question 12 ask about which practice is more useful for reducing waste material during developing a system.84 out of 200 students say that guiding strategic is more useful practice for reducing waste material during development system, 54 out of 200 students say that evaluating is more useful practice for reducing waste material during development system and 62 out of 200 students say that creating alternatives is more useful practice for reducing waste material during development system.

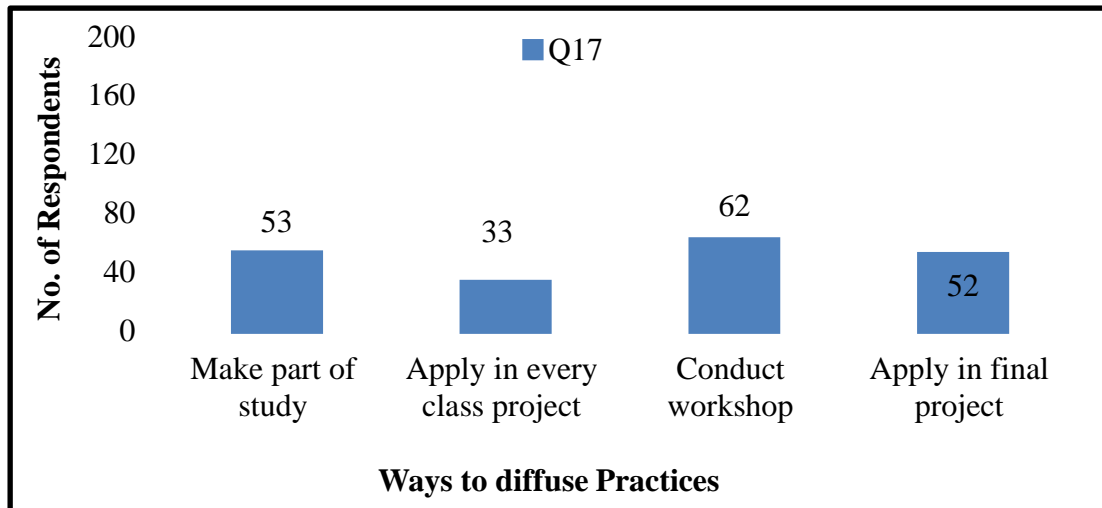
#### **4.5.6 Student Perception on how to Diffuse the Practices of VFT in Software Engineering Education.**

The purpose of directing this part of the survey was to monitor the perception of students on how to diffuse the practices of value-focused thinking in software engineering education. This section of the questionnaire consists of two parts. In the first part a five-point Likert scale ranging from 1 to 5 (Strongly Agree- 5, Agree - 4, Neutral - 3, Disagree- 2, Strongly Disagree – 1). In the second part, a four-point Likert scale ranging from 0.25 to 1 (Make part of study =0.25, Apply in every class project = 0.5, conduct workshop = 0.75, Apply in final year project =1) [33] was provided (explained in Chapter 3). The mean perception on how to diffuse the practices of value-focused thinking was calculated in this section. The detailed value of mean is attached in Appendix F. The results of student's perception on how to diffuse the practices of value-focused thinking in software engineering education are attached in Appendix H. Figure 4.11 shows the student opinions on how to diffuse the practices of value-focused thinking in software engineering education and Figure 4.12 show the opinion of students on the practices of diffusion methods and which method is more suitable to diffuse the practices of value-focused thinking in software engineering education.



**Figure 4.11** Opinion of students about diffusing practices of VFT in Software engineering education

Figure 4.11 shows the perception of students on how to diffuse the practices of VFT in software engineering education. In this section figure show 4 different questions. For Q13 figure show that 62 out of 200 students strongly agree with Q13, 106 out of 200 students agree with Q13, 21 out of 200 students neutral with Q13, and no one out of 200 students disagrees with Q13, and similarly, 11 out of 200 students strongly disagree with Q13. For Q14 figure show that 93 out of 200 students strongly agree with Q14, 84 out of 50 students agree with Q14, 12 out of 200 students Neutral with Q14, and 11 out of 200 students disagree with Q14 and similarly zero out of 200 students strongly disagree with Q14. Similarly for Q15 figure show that 95 out of 200 students strongly agree with Q15, 105 out of 200 students agree with Q15, zero out of 200 students neutral with Q15, and no one out of 200 students disagrees with Q15 and similarly, no one out of 200 students strongly disagrees with Q15. For Q16 figure show that 62 out of 200 students strongly agree with Q16, 96 out of 200 students agree with Q16, 31 out of 200 students neutral with Q16, and 11 out of 200 students disagree with Q16 and no one out of 200 students strongly disagrees with Q16.



**Figure 4.12** According to student the ways how to diffuse practices

Figure 4.12 shows the comparison according to the students between the ways to diffuse the practices of value-focused thinking in software engineering education. In this section figure show that 53 out of 200 students say that practices of value-focused thinking make a part of the study, 33 out of 200 students say that practices of value-focused thinking apply in every class project, 62 out of 200 students say that practices of value-focused diffuse through conduct workshop and 52 out of 200 students say that practices of value-focused thinking apply in the final project.

#### **4.6 Chapter Summary**

This chapter is comprised of four main parts for faculty and similarly the same four-part for students. In the first part of the chapter, the personal information of faculty and student is discussed. In the second part of the chapter, the evaluation results of awareness of value-focused thinking in software engineering education according to both faculty and student perspective are reported. In the third part of the chapter, the evaluation results of practices of value-focused thinking in software engineering education according to both faculty and student perspective are reported. Also, evaluation results of which practice of value-focused thinking in software engineering education is more valuable according to faculty and students are

reported. In the fourth part of the chapter, the evaluation results of how to diffuse the practices of value-focused thinking in software engineering education according to both faculty and student perspective are reported. Also, evaluation results of which method of diffusing practice of value-focused thinking in software engineering education is more suitable according to faculty and students are reported.

The evaluation of the practices of value-focused thinking in software engineering education was related to two aspects; one was the faculty aspect and the other was the student aspect. From the faculty aspect, we evaluated the result based on education and awareness level of value-focused thinking in software engineering education. From student's aspect evaluated the results based on current semester and awareness level of value-focused thinking in software engineering education. Similarly, the evaluation of how to diffuse the practices of value-focused thinking in software engineering education was related to two aspects; one was the faculty aspect and the other was the student aspect. From the faculty aspect, evaluated the result based on education and awareness level of value-focused thinking in software engineering education. From student's aspect evaluated the results based on current semester and awareness level of value-focused thinking in software engineering education.

## CHAPTER 5

### RESULTS AND DISCUSSION

#### 5.1 Research Summary

This study was set out to discover the concept of value-focused thinking in software engineering education. In doing so, this study identified three things. The first thing that identified the respondent's awareness level of value-focused thinking in software engineering education from both faculty and student's perspectives. The second thing that identified the opinions about the practices of value-focused thinking in software engineering education from both faculty and student's perspectives. The third thing that identified the opinions about how to diffuse the practices of value-focused thinking in software engineering education from both faculty and student's perspectives. The study has also identified the most essential practices of value-focused thinking in software engineering education which provide a new era in Software engineering education. The practices of value-focused thinking in software engineering are identified for the Software engineering environment that not only could act as a reference guide but also identify the method how to diffuse the practices in software engineering education.

This research sought to answer three research questions.

RQ1: What is perceived awareness of value-focused thinking in software engineering education?

RQ2: What practices make value-focused thinking in software engineering education?

RQ3: How these practices can be diffused in software engineering education?

The first research question was answered by finding the awareness level of respondents about value-focused thinking in software engineering education. The survey was conducted through a questionnaire to identify the awareness level of respondents about VFT in software engineering education. As a result, according to faculty, 21 faculty members have a basic level of understanding, 14 faculty members have an intermediate level of understanding and 15 faculty members have an advanced level of understanding of value-focused thinking in Software engineering education. Similarly, 40 faculty members' have opinions required to assess to measure the awareness of value-focused thinking in software engineering education. 50 faculty members say that they can use the value-focused thinking method in a university environment as a part of software engineering education. 39 faculty members say that value-focused thinking awareness is essential to reduce human error. 39 faculty members say that all students must be aware of value-focused thinking during the study of software engineering education. 25 faculty members say that awareness of value-focused thinking is important for students before including in software engineering education. Similarly, results according to students 53 have a basic level, 85 students have an intermediate level, 41 students have an advanced level and 21 respondents have an expert level of understanding of VFT in software engineering education. Similarly, 200 students have opinions necessary to assess to measure the awareness of value-focused thinking in software engineering education. 169 students say that they can use the value-focused thinking method in a university environment as a part of software engineering education. 200 students say that value-focused thinking awareness is essential to reduce human error. 169 students say that it is essential for all students to be aware of value-focused thinking during the study of software engineering education. 179 students say that awareness of value-focused thinking is important for the student before including in software engineering education.



The second research question was answered by identifying the opinion of the respondent about practices of VFT in software engineering education. To do so, surveyed through a questionnaire. The survey results helped to identify the opinions of respondents about practices of VFT in software engineering education and to identify the most suitable practice of VFT in software engineering education. Furthermore. As a result, according to faculty, 50 faculty members say that guiding strategic thinking is useful in software engineering education, 50 faculty members say that Evaluating alternatives is useful in software engineering education.

Similarly, 36 faculty members' say that Creating alternatives is useful in software engineering education. 40 faculty members say that Guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education. 25 faculty members say that Guiding strategic thinking is more valuable. 25 faculty members say evaluating alternatives is more valuable. 25 faculty members say which guiding strategic practice is most useful to reduce waste material for you while you would be developing a system. Similarly, results according to students, 200 students say that guiding strategic thinking is useful in software engineering education, 200 students say that Evaluating alternatives is useful in software engineering education. Similarly, 179 students say that Creating alternatives is useful in software engineering education. 157 students say that guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education. 126 students say that guiding strategic thinking is more valuable. 85 students say that which guiding strategic practice is most useful to reduce waste material for you while you would be developing a system.

The third research question was answered by performing a survey through a questionnaire, identifying the way how to diffuse the practices of VFT in software engineering education. As a result according to faculty, 40 faculty members say that including the value-focused thinking practices as a part of undergraduate study in software engineering is a way to diffuse practices in software engineering education. 36 faculty members say that make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in software engineering education. 36 faculty members say that conduct workshops

about the benefits of applying value-focused thinking practices in the project are the way to diffuse the practices in software engineering. 39 faculty members say that make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in software engineering education.26 faculty members say that practices of VFT are diffusing though make a part of the study. According to students, 168 students say that including the value-focused thinking practices as a part of undergraduate study in software engineering is a way to diffuse practices in software Engineering education.177 students say that make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in software engineering education.200 students say that conduct workshops about the benefits of applying value-focused thinking practices in the project are a way to diffuse the practices in software engineering. 39 faculty members say that make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in software engineering education.168 students say that practices of VFT are diffusing though make a part of the study.62 students say that diffusing practices of VFT make ma part of the study.

## **5.2 Fulfillment of Research Objective**

The three research objectives of this research have been attained.

This study provided an evaluated awareness of value-focused thinking in software engineering education faculty and students should aware of while performing their VFT in software engineering education. The study identified 21 faculty members have a basic level of understanding, 14 have an intermediate level of understanding, and 15 have an advanced level of understanding of value-focused thinking in software engineering education. similarly, students 53 have a basic level, 85students have an intermediate level,41students have an advanced level and 21 respondents have an expert level of understanding of VFT in software engineering education. The results are reported in Chapter 4 (Section 4.5.1; section 4.5.4). By achieving Objective 1 provides the awareness of value-focused thinking in software engineering education to faculty and students.

The identification of Practices of VFT in software engineering education was made meaningful by survey and play an important role in the society of software engineering education. All the identified practices of VFT in software engineering education provide a new era to software engineering departments in education. The results are reported in Chapter 4 (Section 4.5.2; section 4.5.5). By achieving this objective 2 provide the practice of VFT in software engineering education which provides support to the software engineering department.

The identification of ways how to diffuse the practices of VFT in software engineering education was meaningful and provide support to the software engineering education department for applying these practices in software engineering education. The results are reported in chapter 4 (section 4.5.3; section 4.5.6). By achieving objective 3, provide the method of how to diffuse VFT practices in software engineering education.

### **5.3 Contribution and Significance of the Study**

This section presents various unique contributions of this research. The contributions of this study are more towards the advances in the software engineering body of knowledge (SWEBOK). The contributions are presented in terms of academic perspectives. Besides this, the contribution in terms of dissemination of knowledge through publications is also reported in this section.

The first contribution was done by identifying and reporting the awareness level of VFT in the software engineering education of respondents. Advances to the existing body of knowledge were made possible by performing the survey with greater availability of published studies and with detailed searching processes. As a result, from a faculty perspective 21 faculty members have a basic level of understanding, 14 faculty members have an intermediate level of understanding and 15 faculty members have an advanced level of understanding of value-focused thinking in software engineering education. Similarly, 40 faculty members' have opinions necessary to assess to measure the awareness of value-focused thinking in software

engineering education. 50 faculty members say that they can use the value-focused thinking method in a university environment as a part of software engineering education. 39 faculty members say that value-focused thinking awareness is essential to reduce human error. 39 faculty members say that all students must be aware of value-focused thinking during the study of software engineering education. 25 faculty members say that awareness of value-focused thinking is important for the student before including in software engineering education. Similarly, results according to students 53 have a basic level, 85 students have an intermediate level, 41 students have an advanced level and 21 respondents have an expert level of understanding of VFT in software engineering education. Similarly, 200 students have the opinion necessary to assess to measure the awareness of value-focused thinking in software engineering education. 169 students say that they can use the value-focused thinking method in a university environment as a part of software engineering education. 200 students say that value-focused thinking awareness is essential to reduce human error. 169 students say that all students must be aware of value-focused thinking during the study of software engineering education. 179 students say that awareness of value-focused thinking is important for the student before including in software engineering education.

The second contribution of this study was to identify the practices of VFT in software engineering education. Through a result, identified the most influential practices of value-focused thinking in software engineering education. According to faculty, 50 faculty members say that guiding strategic thinking is useful in software engineering education, 50 faculty members say that Evaluating alternatives is useful in software engineering education. Similarly, 36 faculty members' say that Creating alternatives is useful in Software engineering education. 40 faculty members say that guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education. 25 faculty members say that guiding strategic thinking is more valuable. 25 faculty members say evaluating alternatives is more valuable. 25 faculty members say which guiding strategic practice is most useful to reduce waste material for you while you would be developing a system. Similarly, results according to students, 200 students say that guiding strategic thinking is useful in software engineering education, 200 students

say that Evaluating alternatives is useful in Software engineering education. Similarly, 179 students say that Creating alternatives is useful in software engineering education. 157 students say that guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education. 126 students say that guiding strategic thinking is more valuable. 85 students say that which guiding strategic practice is most useful to reduce waste material for you while you would be developing a system.

The third contribution was done by identifying how to diffuse the practices of VFT in software engineering education. The practices of VFT in software engineering education would not only act as a reference guideline but would also apply to the software engineering department in education. These practices provide a new era to the Software engineering department in education. As a result according to faculty, 40 faculty members say that including the value-focused thinking practices as a part of undergraduate study in software engineering is a way to diffuse practices in software engineering education. 36 faculty members say that make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in software engineering education. 36 faculty members say that conduct workshops about the benefits of applying value-focused thinking practices in the project are the way to diffuse the practices in software engineering. 39 faculty members say that make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in software engineering education. 26 faculty members say that practices of VFT are diffusing though make a part of the study. According to students, 168 students say that including the value-focused thinking practices as a part of undergraduate study in software engineering is a way to diffuse practices in software Engineering education. 177 students say that make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in software engineering education. 200 students say that conduct workshops about the benefits of applying value-focused thinking practices in the project are the way to diffuse the practices in software engineering. 39 faculty members say that make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in software engineering education. 168 students say that practices of VFT are diffusing though

make a part of the study. 62 students say that diffusing practices of VFT make a part of the study.

#### **5.4 Limitation of Research**

This section reports the restrictions of the study. The survey's target audience of our research was faculty and students of software engineering who were working in the software engineering department in education. Due to our specific focus on value-focused thinking in software engineering education, found that it was very hard to get an appointment from faculty members for their availability. As a result, this study might have contributed to the small sample size. The difficulty in finding the respondents lengthened the gathering of data and the later processes to four months. Due to less reply rate, they did another round of effort sending questionnaires through social media (WhatsApp, Facebook messenger) for their responses. While found that there was no significant difference among the early and late respondents but still receiving responses in two folds might affect its accuracy.

Similar to students' responses, faced difficulty in finding the participants. Due to our specific focus on value-focused thinking in software engineering education, found that it was very hard to get an appointment from students for their availability. As a result, might have contributed to the small sample size. The trouble in finding the respondents lengthened the gathering of data and the later processes to six months. Due to less reply rate, they did another round of effort sending questionnaires through social media (WhatsApp, Facebook messenger) for their responses. While found that there was no significant difference among the early and late respondents but still getting responses in two folds might affect its accuracy. The difficulty in finding the participants according to our selection criterion not only lengthened the evaluation process to 4 months but also restricted us to a small sample size.

Value-focused thinking is a process that decides on the software development process. Value-focused thinking participants faced challenges in identification value-focused thinking in software engineering education. While research on VFT is

rapidly growing, only a few studies focused on VFT in software engineering but none of them targeted VFT in software engineering education and its practices in specific. The absence of such studies restrained the competence of identifying the practices of VFT in software engineering education. Thus, the study can identify the practices of VFT in software engineering education, the most influential practices for software engineering education, and diffuse them into a Software engineering education department. These practices not only acted as a reference guideline for the academicians but also provide a new era to the software engineering education department. Practices of VFT in Software engineering education help the users to enhance their competence towards more accurate and adequate software development.

This research work acted as a foundation towards VFT in the software engineering education department. Our research work focused on VFT in software engineering education. In the future, the other practices of VFT in software engineering education can also be examined for their respective set of Practices in Software engineering education. The researchers can further extend our research work by finding all other practices of VFT in software engineering education. The sample used in this study was limited to those Pakistani universities that worked in a software engineering education environment. In the future, this research can be more support to repeat the survey to other countries also. The addition of other countries might take in new insights to the research.

The major purpose of this research has been successfully achieved. Then, the procedural and analytical content of this research makes an invaluable contribution to the existing literature and institutions of the software engineering departments. This study not only overcomes the knowledge gap but also opens new opportunities for further studies. In conclusion, it is hoped that the faculty and students of the software engineering department working in software engineering education can use this research as a point of reference for understanding, identifying, and diffusing the practices of VFT in the software engineering education department.

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## APPENDIX A

### LIST OF UNIVERSITIES FOR TARGET AUDIENCE

University Name	URL	Address
National University of Modern Languages Islamabad	<a href="http://www.numl.edu.pk">www.numl.edu.pk</a>	4 Khayaban-e-Johar, H 9/4 H-9, Islamabad, Pakistan
Islamic International University Islamabad	<a href="http://www.iiu.edu.pk">www.iiu.edu.pk</a>	H-10, Islamabad, Islamabad, Pakistan
Ripah University	<a href="http://www.ripath.edu.pk">www.ripath.edu.pk</a>	near Hajj Complex, I-14, Islamabad, Pakistan
Bahria University	<a href="http://www.bahria.edu.pk">www.bahria.edu.pk</a>	Shangrilla Rd, E-8/1 E 8/1 E-8, Islamabad, Pakistan
Iqra University	<a href="http://www.iqra.edu.pk">www.iqra.edu.pk</a>	Khayaban-e-Johar, Sector H-9/1 H 9/1 H-9, Islamabad, Pakistan
Nust University	<a href="http://www.nust.edu.pk">www.nust.edu.pk</a>	G-13/1 H-12, Islamabad, Pakistan
Fast University	<a href="http://www.fast.edu.pk">www.fast.edu.pk</a>	A.K. Brohi Road, H-11/4 H 11/4 H-11, Islamabad, Pakistan

<b>University Name</b>	<b>URL</b>	<b>Address</b>
Government College University Faisalabad	<a href="http://www.gcuf.edu.pk">www.gcuf.edu.pk</a>	Kotwali Rd, Gurunankpura, Faisalabad, Pakistan
Comsats University of information and technology.	<a href="http://www.comsats.edu.pk">www.comsats.edu.pk</a>	Park Rd, Islamabad, Pakistan
Mirpur university of science and technology	<a href="http://www.must.edu.pk">www.must.edu.pk</a>	College Rd, New Mirpur City, Azad Jammu, and Kashmir, Pakistan
Comwave Institute	<a href="http://www.comwave.edu.pk">www.comwave.edu.pk</a>	Kashif Plaza, 1st Floor, Block 4B, F-8 Markaz F 8 Markaz F-8, Islamabad, Pakistan
Abasyn University	<a href="http://www.abasyn.edu.pk">www.abasyn.edu.pk</a>	Abasyn University, Park Rd, Meherban Colony Chatta Bakhtawar, Islamabad, Pakistan
Capital University	<a href="http://www.capital.edu.pk">www.capital.edu.pk</a>	Islamabad Expressway, Kahuta, Road Zone-V Sihala, Islamabad, Pakistan

## APPENDIX B

### LIST OF FACULTY TARGET AUDIENCE

<b>ID</b>	<b>Institute</b>	<b>Department</b>
R1	National University of Modern Languages, Islamabad	Software Engineering
R2	National University of Modern Languages, Islamabad	Software Engineering
R3	National University of Modern Languages, Islamabad	Software Engineering
R4	National University of Modern Languages, Islamabad	Software engineering
R5	National University of Modern Languages, Islamabad	Software engineering
R6	National University of Modern Languages, Islamabad	Software engineering
R7	National University of Modern Languages, Islamabad	Software engineering
R8	National University of Modern Languages, Islamabad	Software engineering
R9	National University of Modern Languages, Islamabad	Software engineering
R10	National University of Modern Languages, Islamabad	Software engineering
R11	Islamic International University Islamabad	Software engineering
R12	Islamic International University Islamabad	Software engineering
R13	Islamic International University Islamabad	Software engineering
R14	Islamic International University Islamabad	Software engineering
R15	Islamic International University Islamabad	Software engineering
R16	Islamic International University Islamabad	Software engineering
R17	Islamic International University Islamabad	Software engineering
R18	Islamic International University Islamabad	Software engineering
R19	Islamic International University Islamabad	Software engineering
R20	Islamic International University Islamabad	Software engineering
R21	Bahria University Islamabad	Software engineering
R22	Bahria University Islamabad	Software engineering
R23	Bahria University Islamabad	Software engineering
R24	Bahria University Islamabad	Software engineering
R25	Bahria University Islamabad	Software engineering
R26	Iqra University Islamabad	Software engineering
R27	Iqra University Islamabad	Software engineering
R28	Iqra University Islamabad	Software engineering

R29	Iqra University Islamabad	Software engineering
R30	Ripah University Islamabad	Software engineering
R31	Ripah University Islamabad	Software engineering
R32	Ripah University Islamabad	Software engineering
R33	Nust University Islamabad	Software engineering
R34	Nust University Islamabad	Software engineering
R35	Nust University Islamabad	Software engineering
R36	Fast University Islamabad	Software engineering
R37	Fast University Islamabad	Software engineering
R38	Fast University Islamabad	Software engineering
R39	Government College University Faisalabad	Software engineering
R40	Government College University Faisalabad	Software engineering
R41	Government College University Faisalabad	Software engineering
R42	Government College University Faisalabad	Software engineering
R43	Government College University Faisalabad	Software engineering
R44	Iqra University Islamabad	Software engineering
R45	Iqra University Islamabad	Software engineering
R46	Iqra University Islamabad	Software engineering
R47	Islamic International University Islamabad	Software engineering
R48	Islamic International University Islamabad	Software engineering
R49	National University of Modern Languages, Islamabad	Software engineering
R50	National University of Modern Languages, Islamabad	Software engineering

## APPENDIX C

### LIST OF STUDENT TARGET AUDIENCE

ID	Institute	Program	Semester
R1	National University of Modern Languages Islamabad	BSSE	4th
R2	National University of Modern Languages Islamabad	BSSE	4th
R3	National University of Modern Languages Islamabad	BSSE	4th
R4	National University of Modern Languages Islamabad	BSSE	8th
R5	National University of Modern Languages Islamabad	BSSE	5th
R6	International Islamic University Islamabad	BSSE	6th
R7	National University of Modern Languages Islamabad	BSSE	7th
R8	Government College University, Faisalabad	BSSE	8th
R9	Government College University, Faisalabad	BSSE	5th
R10	National University of Modern Languages	BSSE	5th
R11	Mirpur university of science and technology.	BSSE	7th
R12	National University of Sciences and Technology Islamabad	BSSE	6th
R13	Islamic university Islamabad	BSSE	5th
R14	Bahria university Islamabad	BSSE	7th
R15	International Islamic University Islamabad	BSSE	6th
R16	National University of Sciences and Technology Islamabad	BSSE	5th
R17	Bahria University Islamabad	BSSE	6th
R18	Fast university Islamabad	BSSE	4th
R19	Bahria University Islamabad	BSSE	8th
R20	National university of modern languages Islamabad	BSSE	4th
R21	National University of Modern Languages Islamabad	BSSE	4th
R22	National University of Modern Languages Islamabad	BSSE	4th

R23	National University of Modern Languages Islamabad	BSSE	8th
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R24	National University of Modern Languages Islamabad	BSSE	5th
R25	International Islamic University Islamabad	BSSE	6th
R26	National University of Modern Languages Islamabad	BSSE	7th
R27	Government College University, Faisalabad	BSSE	8th
R28	Government College University, Faisalabad	BSSE	5th
R29	National University of Modern Languages	BSSE	5th
R30	Mirpur university of science and technology	BSSE	7th
R31	National University of Sciences and Technology Islamabad	BSSE	6th
R32	International Islamic University Islamabad	BSSE	5th
R33	Bahria university Islamabad	BSSE	7th
R34	International Islamic University Islamabad	BSSE	6th
R35	National University of Sciences and Technology Islamabad	BSSE	5th
R36	Bahria University Islamabad	BSSE	6th
R37	Fast University Islamabad	BSSE	4th
R38	Bahria University Islamabad	BSSE	8th
R39	National university of modern languages Islamabad	BSSE	4th
R40	National University of Modern Languages Islamabad	BSSE	4th
R41	National University of Modern Languages Islamabad	BSSE	4th
R42	National University of Modern Languages Islamabad	BSSE	8th
R43	National University of Modern Languages Islamabad	BSSE	5th
R44	International Islamic University Islamabad	BSSE	6th
R45	National University of Modern Languages Islamabad	BSSE	7th
R46	Government College University, Faisalabad	BSSE	8th
R47	Government College University, Faisalabad	BSSE	5th
R48	National University of Modern Languages	BSSE	5th
R49	Mirpur university of science and technology	BSSE	7th
R50	National University of Sciences and Technology Islamabad	BSSE	6th
R51	International Islamic University Islamabad	BSSE	5th
R52	Bahria university Islamabad	BSSE	7th
R53	International Islamic University Islamabad	BSSE	6th
R54	National University of Sciences and Technology Islamabad	BSSE	5th
R55	Bahria University Islamabad	BSSE	6th
R56	Fast University Islamabad	BSSE	4th
R57	Bahria University Islamabad	BSSE	8th



R58	National university of modern languages Islamabad	BSSE	4th
R59	National University of Modern Languages Islamabad	BSSE	4th
R60	National University of Modern Languages Islamabad	BSSE	4th
R61	National University of Modern Languages Islamabad	BSSE	8th
R62	National University of Modern Languages Islamabad	BSSE	5th
R63	International Islamic University Islamabad	BSSE	6th
R64	National University of Modern Languages Islamabad	BSSE	7th
R65	Government College University, Faisalabad	BSSE	8th
R66	Government College University, Faisalabad	BSSE	5th
R67	National University of Modern Languages	BSSE	5th
R68	Mirpur university of science and technology	BSSE	7th
R69	National University of Sciences and Technology Islamabad	BSSE	6th
R70	International Islamic University Islamabad	BSSE	5th
R71	Bahria University Islamabad	BSSE	7th
R72	international Islamic university Islamabad	BSSE	6th
R73	National University of Sciences and Technology Islamabad	BSSE	5th
R74	Bahria University Islamabad	BSSE	6th
R75	Fast University Islamabad	BSSE	4th
R76	Bahria University Islamabad	BSSE	8th
R77	National university of modern languages Islamabad	BSSE	4th
R78	National University of Modern Languages Islamabad	BSSE	4th
R79	National University of Modern Languages Islamabad	BSSE	4th
R80	National University of Modern Languages Islamabad	BSSE	8th
R81	National University of Modern Languages Islamabad	BSSE	5th
R82	International Islamic University Islamabad	BSSE	6th
R83	National University of Modern Languages Islamabad	BSSE	7th
R84	Government College University, Faisalabad	BSSE	8th
R85	Government College University, Faisalabad	BSSE	5th
R86	National University of Modern Languages	BSSE	5th
R87	Mirpur university of science and technology	BSSE	7th
R88	National University of Sciences and Technology Islamabad	BSSE	6th
R89	International Islamic University Islamabad	BSSE	5th
R90	Bahria University Islamabad	BSSE	7th
R91	International Islamic university Islamabad	BSSE	6th
R92	National University of Sciences and Technology Islamabad	BSSE	5th

R93	Bahria University Islamabad	BSSE	6th
R94	Fast university Islamabad	BSSE	4th
R95	Bahria University Islamabad	BSSE	8th
R96	Fast University Islamabad	BSSE	4th
R97	Fast University Islamabad	BSSE	4th
R98	Fast University Islamabad	BSSE	4th
R99	Fast University Islamabad	BSSE	8th
R100	Fast University Islamabad	BSSE	5th
R101	National university of modern languages Islamabad	BSSE	6th
R102	National University of Modern Languages Islamabad	BSSE	7th
R103	National University of Modern Languages Islamabad	BSSE	8th
R104	National University of Modern Languages Islamabad	BSSE	5th
R105	National University of Modern Languages Islamabad	BSSE	5th
R106	International Islamic University Islamabad	BSSE	7th
R107	National University of Modern Languages Islamabad	BSSE	6th
R108	Government College University, Faisalabad	BSSE	5th
R109	Government College University, Faisalabad	BSSE	7th
R110	National University of Modern Languages	BSSE	6th
R111	Mirpur university of science and technology	BSSE	5th
R112	National University of Sciences and Technology Islamabad	BSSE	6th
R113	International Islamic University Islamabad	BSSE	4th
R114	Bahria university Islamabad	BSSE	8th
R115	International Islamic university Islamabad	BSSE	4th
R116	National University of Sciences and Technology Islamabad	BSSE	4th
R117	Bahria University	BSSE	4th
R118	Fast university Islamabad	BSSE	8th
R119	Bahria University Islamabad	BSSE	5th
R120	Government College University, Faisalabad	BSSE	6th
R121	Comsat University Islamabad	BSSE	7th
R122	Comsat University Islamabad	BSSE	8th
R123	Comsat University Islamabad	BSSE	5th
R124	Comsat University Islamabad	BSSE	5th
R125	Comsat University Islamabad	BSSE	7th
R126	Comsat University Islamabad	BSSE	6th
R127	National university of modern languages Islamabad	BSSE	5th
R128	National University of Modern Languages Islamabad	BSSE	7th
R129	National University of Modern Languages Islamabad	BSSE	6th
R130	National University of Modern Languages	BSSE	5th

R131	National University of Modern Languages Islamabad	BSSE	6th
R132	International Islamic university Islamabad	BSSE	4th
R133	National University of Modern Languages Islamabad.	BSSE	8th
R134	Government College University, Faisalabad	BSSE	4th
R135	Government College University, Faisalabad	BSSE	4th
R136	National University of Modern Languages	BSSE	4th
R137	Mirpur university of science and technology	BSSE	8th
R138	National University of Sciences and Technology Islamabad	BSSE	5th
R139	International Islamic university Islamabad	BSSE	6th
R140	Bahria university Islamabad	BSSE	7th
R141	International Islamic university Islamabad	BSSE	8th
R142	National University of Sciences and Technology Islamabad	BSSE	5th
R143	Bahria University Islamabad	BSSE	5th
R144	FAST university Islamabad	BSSE	7th
R145	Bahria University Islamabad	BSSE	6th
R146	Iqra university Islamabad	BSSE	5th
R147	Iqra university Islamabad	BSSE	7th
R148	Iqra university Islamabad	BSSE	6th
R149	Iqra university Islamabad	BSSE	5th
R150	Iqra university Islamabad	BSSE	6th
R151	National university of modern languages Islamabad	BSSE	4th
R152	National University of Modern Languages Islamabad	BSSE	8th
R153	National University of Modern Languages Islamabad	BSSE	4th
R154	National University of Modern Languages Islamabad	BSSE	4th
R155	National University of Modern Languages Islamabad	BSSE	4th
R156	International Islamic university Islamabad	BSSE	8th
R157	National University of Modern Languages Islamabad	BSSE	5th
R158	Government College University, Faisalabad	BSSE	6th
R159	Government College University, Faisalabad	BSSE	7th
R160	National University of Modern Languages	BSSE	8th
R161	Mirpur university of science and technology	BSSE	5th
R162	National University of Sciences and Technology Islamabad	BSSE	5th
R163	International Islamic university Islamabad	BSSE	7th
R164	Bahria university Islamabad	BSSE	6th
R165	International Islamic university Islamabad	BSSE	5th
R166	National University of Sciences and Technology Islamabad	BSSE	7th

R167	Bahria University Islamabad	BSSE	6th
R168	Fast university Islamabad	BSSE	5th
R169	Bahria University Islamabad	BSSE	6th
R170	Abasyn University Islamabad	BSSE	4th
R171	Abasyn University Islamabad	BSSE	8th
R172	Abasyn University Islamabad	BSSE	4th
R173	Abasyn University Islamabad	BSSE	4th
R174	National university of modern languages Islamabad	BSSE	4th
R175	National University of Modern Languages Islamabad	BSSE	8th
R176	National University of Modern Languages Islamabad	BSSE	5th
R177	National University of Modern Languages Islamabad	BSSE	6th
R178	National University of Modern Languages Islamabad	BSSE	7th
R179	International Islamic university Islamabad	BSSE	8th
R180	National University of Modern Languages Islamabad	BSSE	5th
R181	Government College University, Faisalabad	BSSE	5th
R182	Government College University, Faisalabad	BSSE	7th
R183	National University of Modern Languages	BSSE	6th
R184	Mirpur university of science and technology	BSSE	5th
R185	National University of Sciences and Technology Islamabad	BSSE	7th
R186	International Islamic university Islamabad	BSSE	6th
R187	Bahria University Islamabad	BSSE	5th
R188	International Islamic university Islamabad	BSSE	6th
R189	National University of Sciences and Technology Islamabad	BSSE	4th
R190	Bahria University Islamabad	BSSE	8th
R191	Fast university Islamabad	BSSE	4th
R192	Bahria University Islamabad	BSSE	4th
R193	Capital University Islamabad	BSSE	4th
R194	Comwave Institute Islamabad	BSSE	8th
R195	Comwave Institute Islamabad	BSSE	5th
R196	Comwave Institute Islamabad	BSSE	6th
R197	Comwave Institute Islamabad	BSSE	7th
R198	Comwave Institute Islamabad	BSSE	8th
R199	Comwave Institute Islamabad	BSSE	5th
R200	Comwave Institute Islamabad	BSSE	5th

## **APPENDIX D**

### **SURVEY QUESTIONNAIRE FOR FACULTY AND STUDENTS**

#### **Section:1 Personal information for faculty**

Name: \_\_\_\_\_ Institute: \_\_\_\_\_

Department: \_\_\_\_\_ Program: \_\_\_\_\_

Qualification: \_\_\_\_\_ Gender: \_\_\_\_\_

#### **Section:1 Personal information for students**

Name: \_\_\_\_\_ Institute: \_\_\_\_\_

Department: \_\_\_\_\_ Program: \_\_\_\_\_

Semester: \_\_\_\_\_ Gender: \_\_\_\_\_

#### **Section:2 Awareness**

This section is based on our RQ1 which is mention below. The objective of this question to identify the awareness of Value-focused thinking in Software engineering education.

RQ1: What is perceived awareness of value-focused thinking in Software engineering education?

What is Value-Focused Thinking (VFT)?

“Value-Focused Thinking (VFT) puts values at the center of decision-making. Having explicit values makes it easier to rank existing alternatives, generate new alternatives, communicate and negotiate, and identify new decision opportunities to pursue.”

1) What is your level regarding value-focused thinking awareness?

Basic  Intermediate  Advance  Expert

<b>Questions:</b>	<b>SA</b>	<b>A</b>	<b>N</b>	<b>D</b>	<b>SD</b>
2) Do you think it is necessary to assess to measure the awareness of value-focused thinking in Software engineering education?					
3) Would you think can use the value-focused thinking method in a university environment as a part of Software engineering education?					
4) Would you think value-focused thinking awareness is essential to reduce human error?					
5) Do you think all students must be aware of value-focused thinking during the study of Software engineering education?					
6) Would you think awareness of value-focused thinking is important for students before including it in Software engineering education?					

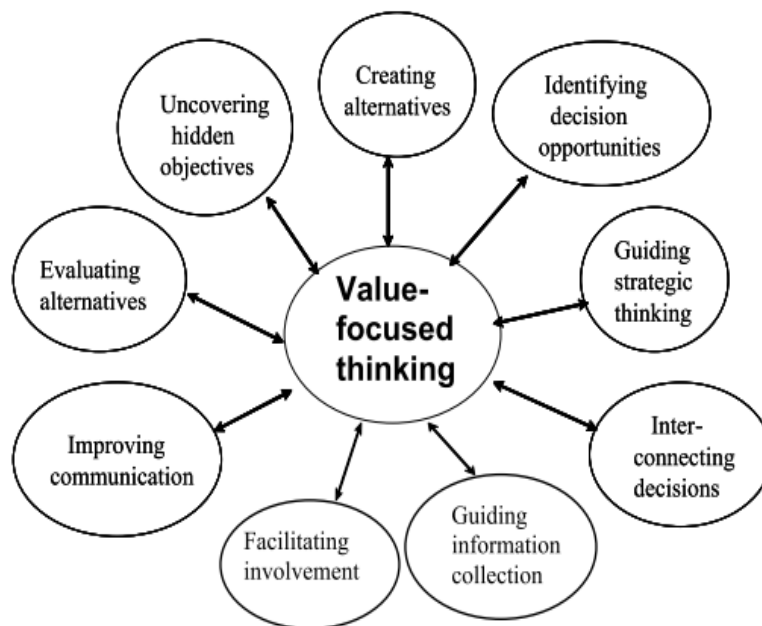
### Section:3 Practices

(Guiding strategic thinking, evaluating alternatives, Creating alternatives)

This section is based on our RQ2 which is mention below. The objective of this question to identify the practices of Value-focused thinking in Software engineering education.

RQ2: What practices make value-focused thinking in Software engineering education?

“Keeney identifies nine benefits of value-focused thinking. Although most of these benefits are self-explanatory, three are especially relevant to operational analysis. The first is guiding strategic thinking: value-focused thinking can capture the commander’s intent for courses of action. The second is evaluating alternatives: multiple objective decision analysis can evaluate alternative courses of action. The third is creating alternatives: once alternatives are evaluated; they can assess the value gaps (the difference between the ideal value and the best alternative) and focus our effort to develop better alternatives.”



<b>Questions:</b>	<b>SA</b>	<b>A</b>	<b>N</b>	<b>D</b>	<b>SD</b>
7) Would you think Guiding strategic thinking is useful in Software engineering education?					
8) Do you think Evaluating alternatives is useful in Software engineering education?					
9) Do you think Creating alternatives is useful in Software engineering education?					
10) Would you think Guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education?					

11) According to you which practice is more valuable?

Guiding strategic thinking  Evaluating alternatives  Creating alternatives

12) According to you which practice is most useful to reduce waste material for you while you would be developing a system?

Guiding strategic thinking  Evaluating alternatives  Creating alternatives

#### **Section:4 How practices can be diffused**

This section is based on our RQ3 which is mention below. The objective of this question to generate an approach for diffusing value-focused thinking in Software engineering education.

RQ3: How these practices can be diffused in Software engineering education?



Questions:	SA	A	N	D	SD
13) Would you think including the value-focused thinking practices as a part of undergraduate study in Software engineering is a way to diffuse practices in Software engineering education?					
14) Do you think make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in Software engineering education?					
15) Do you think conduct workshops about the benefits of applying value-focused thinking practices in the project is a way to diffuse the practices in Software engineering education?					
16) Do you think make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in Software engineering education?					

17) What action can take to diffuse value-focused thinking practices in Software engineering education?

- Make part of the study  
 Apply in every class project  
 Conduct workshop  
 Apply in the final project

## **Invitation Letter**

Dear Respondent:

I am an MPhil Student at the National university of modern languages Islamabad (NUML). I request you to help to identify the awareness of VFT in Software engineering education, practices of VFT in Software engineering education may change the situations during studying Software engineering.

We would greatly appreciate it if you could complete this questionnaire which comprises four sections. Section 1 comprises questions related to the personal information of the respondent. Section 2 comprises questions related to the practices of VFT in Software engineering education and Section 3 asks you about how to diffuse the practices of VFT in Software engineering education The Estimated time for completion of this questionnaire is about 20 minutes.

All information that you provide will remain confidential and will be only used for our analyses. Your personal information like name, email; will be used for administrative purposes only to direct the reviewer or evaluation team to contact you if necessary. If you have any questions about this survey, feel free to contact me by email (m.umarsultan786@gmail.com). Results from this study will provide situational awareness, identify practices, and how to diffuse the practices of VFT in Software engineering education which can be shareable with you if you are interested in it.

Thank you for your participation.

## APPENDIX E

### MEAN VALUE OF FACULTY RESPONSES

Sr. No	Questions	Mean value
1	What is your level regarding value-focused thinking awareness?	12.5
2	Do you think it is necessary to do an assessment to measure the awareness of value-focused thinking in Software engineering education?	10
3	Would you think can use the value-focused thinking method in a university environment as a part of Software engineering education?	10
4	Would you think value-focused thinking awareness is essential to reduce human error?	10
5	Do you think all students must be aware of value-focused thinking during the study of Software engineering education?	10
6	Would you think awareness of value-focused thinking is important for the student before including in Software engineering education?	10
7	Would you think Guiding strategic thinking is useful in Software engineering education?	8.333
8	Do you think Evaluating alternatives is useful in Software engineering education?	8.333
9	Do you think Creating alternatives is useful in Software engineering education?	8.333
10	Would you think Guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education?	8.333
11	According to you which practice is more valuable?	16.666

12	According to you which practice is most useful to reduce waste material for you while you would be developing a system?	16.666
13	Would you think including the value-focused thinking practices as a part of undergraduate study in Software engineering is a way to diffuse practices in Software engineering education?	10
14	Do you think make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in Software engineering education?	10
15	Do you think conduct workshops about the benefits of applying value-focused thinking practices in the project is a way to diffuse the practices in Software engineering education?	10
16	Do you think make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in Software engineering education?	10
17	What action can take to diffuse value-focused thinking practices in Software engineering education?	12.5

## APPENDIX F

### MEAN VALUE OF STUDENT RESPONSES

Sr. No	Questions	Mean value
1	What is your level regarding value-focused thinking awareness?	50
2	Do you think it is necessary to do an assessment to measure the awareness of value-focused thinking in Software engineering education?	40
3	Would you think they can use the value-focused thinking method in a university environment as a part of Software engineering education?	40
4	Would you think value-focused thinking awareness is essential to reduce human error?	40
5	Do you think all students must be aware of value-focused thinking during the study of Software engineering education?	40
6	Would you think awareness of value-focused thinking is important for the student before including in Software engineering education?	40
7	Would you think Guiding strategic thinking is useful in Software engineering education?	33.333
8	Do you think Evaluating alternatives is useful in Software engineering education?	33.333
9	Do you think Creating alternatives is useful in Software engineering education?	33.333
10	Would you think Guiding strategic thinking, evaluating alternatives, and Creating alternatives necessary to include at university level education?	33.333
11	According to you which practice is more valuable?	66.666

12	According to you which practice is most useful to reduce waste material for you while you would be developing a system?	66.666
13	Would you think including the value-focused thinking practices as a part of undergraduate study in Software engineering is a way to diffuse practices in Software engineering education?	40
14	Do you think to make compulsory to apply value-focused thinking practices in the class base project is a way to diffuse the practices in Software engineering education?	40
15	Do you think conduct workshops about the benefits of applying value-focused thinking practices in the project is a way to diffuse the practices in Software engineering education?	40
16	Do you think make compulsory to apply value-focused thinking practices in the final year project is a way to diffuse the practices in Software engineering education?	40
17	What action can take to diffuse value-focused thinking practices in Software engineering education?	50

## APPENDIX G

### SURVEY RESULTS OF FACULTY RESPONDENTS

#### Section:2 Awareness

Q#01		Basic	Intermediate	Advance	Expert
		21	14	15	0
	SA	A	N	DA	SDA
Q#02	29	11	10	0	0
Q#03	15	35	0	0	0
Q#04	25	14	11	0	0
Q#05	39	0	0	11	0
Q#06	11	14	25	0	0

#### Section:3 Practices

	SA	A	N	DA	SDA
Q#07	29	21	0	0	0
Q#08	15	35	0	0	0
Q#09	25	11	14	0	0
Q#10	26	14	10	0	0
	<b>Guiding strategic thinking</b>		<b>Evaluating alternatives</b>		<b>Creating alternatives</b>
Q#11	25		25		0
Q#12	25		10		15

**Section:4 How practices can be diffused**

	<b>SA</b>	<b>A</b>	<b>N</b>	<b>DA</b>	<b>SDA</b>
Q#13	25	15	10	0	0
Q#14	11	25	0	14	0
Q#15	15	21	14	0	0
Q#16	39	0	11	0	0
	<b>Make part of study</b>	<b>Apply in every class project</b>	<b>Conduct workshop</b>	<b>Apply in final project</b>	
Q#17	26	10	0	14	



## APPENDIX H

### SURVEY RESULTS OF STUDENT RESPONDENTS

#### Section:2 Awareness

Q#01		Basic	Intermediate	Advance	Expert
		53	85	41	21
	SA	A	N	DA	SDA
Q#02	115	85	0	0	0
Q#03	68	101	17	14	0
Q#04	102	98	0	0	0
Q#05	107	62	31	0	0
Q#06	73	106	21	0	0

#### Section:3 Practices

	SA	A	N	DA	SDA
Q#07	105	95	0	0	0
Q#08	72	128	0	0	0
Q#09	84	95	21	0	0
Q#10	105	52	43	0	0
	Guiding strategic thinking		Evaluating alternatives		Creating alternatives
Q#11	126		21		53
Q#12	84		54		62

**Section:4 How practices can be diffused**

	<b>SA</b>	<b>A</b>	<b>N</b>	<b>DA</b>	<b>SDA</b>
Q#13	62	106	21	0	11
Q#14	93	84	12	11	0
Q#15	95	105	0	0	0
Q#16	62	96	31	11	0
	<b>Make part of study</b>	<b>Apply in every class project</b>	<b>Conduct workshop</b>	<b>Apply in final project</b>	
Q#17	53	33	62	52	

## **APPENDIX I**

### **LIST OF PUBLICATIONS**

#### **1. Journal of Systems and Software**

Instrument to investigate Value Focused Thinking in Software Engineering Education.

#### **2. IEEE ACCESS**

Empirical investigation on value focused thinking among university students and faculty members of Pakistan