I.J. Modern Education and Computer Science, **2022, 3, 26-44**
Published Online June 2022 in MECS (http://www.mecs-press.org/)
DOI: 10.5815/ijmecs.2022.03.02

Definition Synthesis of Agility in Software Development: Comprehensive Review of Theory to Practice

Necmettin Ozkan
Information Technologies Research and Development Center, Kuveyt Turk Participation Bank, Kocaeli, Turkey
E-mail: necmettin.ozkan@kuveytturk.com.tr

Mehmet Sahin Gok
Department of Business, Gebze Technical University, Kocaeli, Turkey
E-mail: sahingok@gtu.edu.tr

Received: 16 September 2021; Revised: 13 December 2021; Accepted: 19 March 2022; Published: 08 June 2022

Abstract: Software development agility has been regarded as a critical pillar of modern businesses. However, there is still a way to find whether there exists a consistent, complete, precise, agreed and uniformed definition of it. In this regard, this study firstly reviews the existing definitions of agility in the software development domain from the literature. As one of the main results of this phase, we have seen that although agility has a remarkable root in the software development domain, even its definition is still debatable and there are other concepts close to agility in terms of definition but used interchangeably. There is another confusion about how some researchers define agility over other different concepts, although there is no apparent unifying factor in their origins except their historical co-occurrence. In addition, there are particular practices embedded into the agility definitions mostly from the manifesto and Scrum. After uncovering the deficiencies of the existing definitions, we aimed to ratify the definition of the agility concept. Then, we intended to synthesize the underlying facets of the identified definitions and propose a new yet more comprehensive definition revealing the agility characteristics properly by considering the interpretations of the existing definitions. Our study stands out by using a customized synthesis method for analysis, providing inputs to this analysis with a comprehensive literature review, and the comprehensive evaluation of the facets with the support of the literature. We are aware that agreeing on a definition is a valuable exercise and a good starting point for a better understanding of the agility phenomenon that could enable and lead to more realistic implementations, less disappointment and disillusionment, and possibly greater success rates for both practitioners and researchers.

Index Terms: Agile, Agility, Flexibility, Adaptation, Response, Software Development, SLR, Systematic Literature Review

1. Introduction

Information system/technology agility has been highlighted as a critical pillar of modern businesses [1]. In particular, software development as a complex domain adopts increasingly more agile approaches and has nowadays reached wide adoption [2]. The basic idea of agile software development is to manage complexity with the need to be able to respond to change [3]. Nevertheless, it is interesting that while the notion of agility in the software development domain is not new, the term has no consistent, complete, precise, agreed, uniformed and standard definition yet [4, 5, 6, 7, 8, 9, 10, 11, 12].

As Turner [13] pointed out, there are nearly as many definitions of agility as there are agile practitioners. In that case, the understanding and definition of agility remarkably vary [14]. As a result, many practitioners are confused about agility [15]. This confusion involves practitioners [15, 16], theorists [16], and even the recognized gurus [17]. As a result, the definition of agility in software development has not been well understood; people do mean different things when they are talking about the concept [17]. Moreover, organizations implement agile approaches without a clear understanding of how to define the word of agility [18].

People's different agility perceptions make application and evaluation of it very challenging [17, 19]. The definitions can also be taken to promise what Agile Software Development has to offer. Its misleading definitions will create unrealistic results, which will ultimately damage Agile itself. Inaccurate definitions and the corresponding base

that such definitions establish will negatively affect all other Agile phenomena (frameworks, organizations, teams, etc.) built on that base. As long as agility and its attributes cannot be defined, it is hard to understand how a software development method might contribute to a development team's ability to be agile [20]. Hence, it is not feasible to discuss the effectiveness and value of Agile methods [21]. For instance, whatever is constructed on an agility definition directly proportional to speed, synonymous with flexibility or constrained firmly by adaptation, naturally deviates organizations from accurate agility and its benefits. As a result, a more in-depth understanding of the agility concept is crucial.

Apart from the studies providing their agility definitions, as for now in the academic literature, study [17] (not systematically) reviewed the definitions of agility in the software development domain up until 2013 and listed a range of facets of agility. To clarify the meaning of agility, Conboy, and Fitzgerald [22] and Conboy [23], the extended version of the former one, carried out a (not systematic) literature review on the concept of agility across several disciplines, including management, manufacturing and business. They also distinguished intertwined concepts of flexibility and leanness along with their relationship with agility. Then, they form the iterative definition of agility by merging underlying aspects from flexibility and leanness. Apart from these two studies, we have not encountered any other study that reviews the definitions of agility in the field of software development. This situation implies that there is still no systematic and up-to-date (covering also the last decade) study in this area.

Motivated with this gap, this paper first aims to review the existing definitions of agility from the literature. Then, it discovers and synthesizes the underlying facets of the identified definitions. The paper uncovers the inadequacy of existing definitions and provides conceptual differentiation among the agility concept with other similar paradigms (such as flexibility, adaptability, leanness, robustness) to describe agility and proposes an overarching definition of it for software development. Additionally, the process of agility is proposed to realize the inner mechanism experienced during agility actions, then to reach and serve for a clearer and healthier definition of agility. Consequently, this study focuses on three main issues:

- Identifying current definitions of agility in software development domain from the literature
- Investigating at what extent they provide a proper definition for each individual source and in general
- If there is a lack of a proper definition at the final, proposing an overarching one based on the appropriate parts of the previous definitions and after clarifications of the relevant concepts with the support of the literature

Our study stands out with its up-to-date coverage, benefiting from the non-IT definitions, using a method for analysis, providing inputs to this analysis and synthesis with a comprehensive literature review, and the comprehensive evaluation of the facets with the support of the literature. The paper's strength is that it aims to solve a large problem in finding the overarching definition of agility. Since there are a lot of definitions already in existence, taking on the multitude of definitions is a key strength in attempting to fill the gap. Additionally, one other strength is its access to a large amount of updated research with definitions of agility. In terms of proposing a definition, most of the studies provide a "take it or leave it" definition [23]. Unlike them, the definition of agility in our study is developed step by step, through a deep investigation and evaluation of all relevant facets.

The paper is organized as follows. Section 2 outlines the background for the process of agility that will be used in the further stages of the paper, especially during the development of the new definition of agility. Section 3 depicts the proposed method applied in the study. Section 4 delivers the details of the literature review along with its results. Section 5 elaborates the concepts encountered during the literature review stage as the relevant ones to agility concepts to clarify their difference, similarity and correspondence. Section 6 provides discussions on the current definitions and proposes a new one based on the background and baseline in Section 2 and 5. Finally, Section 7 delivers conclusions and limitations.

2. Background: Process of Agility

As any process, the agility process starts with a trigger. This trigger may be a change or a need for creating an action desired to be produced for a possible change that will be happening. The trigger can come from outside or from inside the entity's system. An example from inside is the emergence of the system's self-improvement need as a trigger coming from within the system. This change can be any kind of predicted or unpredictable, expected or unexpected change. Making a change is another step. This step happens first in reactive behaviors and after in proactive behaviors by anticipating. The issue is that the later the entity detects it, the more time, money, and defects will be incurred [22]. After or before a change is happening, sensing and anticipating it (what is happening, or what will be happening) is the next step. Sensing is about detecting and collecting data from the source that suggests the need for change [1]. After sensing and anticipating, diagnosing, filtering, and interpreting input data occurs [1]. The entity evaluates and decides on what response to prepare. This response can also be null (including not delivering any response). The last step is the execution of the prepared response. This stage is where flexibility also plays a role; an inflexible entity may find executing a given response harder than a flexible one does. However, a flexible organization may not be agile if it is unable to detect and decide quickly and appropriately [1] and unable to make quick sensing (detecting and anticipating)

[24, 25] or able to do so with a wrong sensing and responding that could be fatal for the significance of agility [25].

3. Research Method

Agility is not a concept unique to software development [22]. Indeed, it first appeared in the mainstream business literature in 1991, when a group of researchers at the Iacocca Institute in Lehigh University introduced the term "agile manufacturing" [26]. However, as argued by Conboy and Fitzgerald [22], "the search for a definitive, all-encompassing concept of agility is not to be found simply through an examination of agility in other fields" that are having the same problems as those studying agile methods in software development. Instead, it is to be found through an examination of the underlying concepts of agility. Thus, this paper aims to develop a comprehensive conceptual definition of agility applicable to the software development domain by considering useful definitions in other fields, enabling a more satisfactory agility degree. To do so, we applied an exploratory, inductive research design to synthesize primary studies for the purpose of making contributions beyond those achieved in the original studies, as proposed by Hoon [27]. It involves the accumulation of previous studies' evidence, and more specifically its extraction, analysis, and synthesis in empirically consolidating primary studies [27]. To come up with a customized method for that purpose, we were inspired by Hoon [27] which fits well into our study's context. Accordingly, we applied these research process steps:

- **Framing the Research Question/Objective:** The research objective of this paper is to describe and discuss the definition of agility in detail; and then to propose a formal definition of it for the software development domain. With this purpose, the study aims to reach other related studies and related contents in the literature.
- **Locating Relevant Research:** A literature review on the concept of agility was conducted. This review includes research on agility in software development primarily and Information Technology/Information System (IT/IS) domain secondarily, and in other domains such as manufacturing, business, organizational agility lastly. When it provides a domain-independent agility definition to serve our purpose, we appreciate the multidisciplinary nature and evolution of the concept.
- **Inclusion/Exclusion Criteria:** The next step is to determine the appropriate inclusion of relevant studies by defining and applying the inclusion and exclusion criteria to ensure the synthesis's validity [28].
- **Extracting Data:** The definitions of each agility and agility-related terms were extracted regarding the literature review.
- **Analysis at Individual Case Level:** It is essential to analyze each case (each definition in our case) individually to achieve the main objective of our study.
- **Synthesizing Findings in the Analyzed Cases:** The definitions of related terms and agility are then merged to form a definition of agility. This definition is then subsequently justified in the light of the agility process description proposed in this study. Given the literature's diversity, the researchers intend to ensure that the definition represents agility in its most general sense in the domain. Due to each of these terms' broad nature and the diverse interpretations of these terms that exist, it is better to allow the definition of agility constructed and adjusted incrementally.

This method fits well to facilitate research objectives. Rather than applying a standard systematic literature review, we get the core part of it needed to identify related studies in the literature, then by going further, our method analyzes each individual definition and synthesizes individual definitions to merge them to form a new definition of agility. Given the literature's diversity and agility's broad nature and diverse interpretations, the method helps to reach an inclusive, explicit and incrementally constructed agility definition.

4. Literature Review

The literature was reviewed to identify the studies that include definition(s) of agility in the literature. The review method was determined iteratively. In the first iteration, to determine the appropriate keywords, a preliminary search was conducted in Google Scholar with the word "agile" instead of "agility", and the first 100 returned results were examined to decide whether to include the word "agile" in the keywords. We realized that with the word "agile", the studies that define agile-related methods, frameworks, and agile software development itself, not a definition of agility, were returned, and we did not include this word in our further search as they do not provide an agility definition. Regarding the search location, in the second iteration, we first examined the effect of searching in metadata instead of the full text by performing a metadata search in all of the libraries, including IEEE Xplore, Wiley, Taylor, DOAJ, DBLP, and Web of Science, with the keyword in the Table 1. A total of 16 results were returned from the search results, insufficient to cover up relevant resources (This result also indicates that the number of studies aiming to mainly define agility is relatively low).

Consequently, we have concluded that our scope's relevant studies cannot be included in the metadata. The search location was then expanded to full text in the last iteration. The review was done with the keywords in Table 1, between 16/12/2020 and 20/12/2020. For the selection of papers, the following propositions of exclusion criteria (EC) were

specified and applied:

EC1: Papers not available in English.

EC2: Papers published in non-peer-reviewed sources such as thesis, web pages, and books (Although these resources are likely to contain useful information in our scope, they are unlikely to be systematically reviewed).

EC3: Papers not accessible by the authors

A total number of 179 peer-reviewed works were returned from the search results seen in Table 1. After removing seven duplicate records, 172 distinct works were reached. Additionally, nine papers were added after examining those 172 papers as relevant studies. They are deemed by the corresponding paper making the total number of 181 distinct papers. Among them, four papers were not accessible online (EC3 in relevant) as there is no full text of them as soft copy on the web. Apart from these, five of them are not accessible by the authors even though they have restricted accesses (EC3 in relevant), and nine of them are not peer-reviewed (EC2 in relevant). The remaining 163 papers were examined through their full texts to identify a definition of agility inside the paper.

To find the relevant definition contents inside the papers, the search with the keyword of "defin" (representing "define", "defines", "definition", "definitions") was done. In addition to the explicit definitions inside the papers, if it is stated by the companion paper that a definition is provided relating to our scope without any explicit definition, these studies were also examined, but were not included in the total number of the results. We have already seen that all such citations are included in our searches. For the definitions detected inside papers, the following propositions of inclusion criteria (IC) and exclusion criteria (EC) were specified and applied:

IC1: Definitions of agility in software process and development and IS/IT domain

IC2: Definitions of agility in other than software process and development and IS/IT domain but not specific to that domain and usable to include in our study

EC4: Definitions specific to enterprise agility, strategic agility, agile manufacturing and supply chain agility, and such.

EC5: Definitions of Agile software development methods, frameworks, models, maturity models etc.

EC6: Definitions consists of full of (Agile) practices (elaborated further as below)

It has been seen that 78 papers provide agility definitions in specific domains other than IT, just mentioning the term "software". Even, the paper itself mainly does not refer to the software. Their coverage includes agility in data center, aircraft, anatomy, assembly systems, business, cybersecurity, defense employee, power systems, engineering systems, enterprise, logistics, manufacturing marketing, organization, robotic, service-oriented e-commerce systems, sports, supply chain, system-of-systems, systems engineering, and website agility. Those papers were excluded by considering EC4. Among those excluded, 34 papers do not provide any kind of agility definition. A considerable number of studies (39 of them) cite agility definitions from the other original papers, either included in our review or otherwise (as they are not peer-reviewed papers) added to our list directly. It has been observed that frequently encountered references are to the following (regardless of any order): study [22, 23, 29, 30, 31]. Additionally, 12 papers (pointed as "SLR" in "Place" column of Table 2) provide their agility definitions within the scope of our study. The whole process is depicted in Fig. 1.

Table 1. Result for Literature Review for Agility Definitions

Library	Key Word	Place	# of Results
ACM Digital Library	(("define agility" OR "defines agility" OR "agility definition" OR "agility definitions" OR "definitions of agility" OR "definition of agility") AND software)	Full text	18
IEEE Xplore			73
Wiley			34
Taylor & Francis			26
DOAJ*		Meta-data	0
DBLP*			3
Web of Science*			10
Google Scholar**	(Agile OR Agility) AND (definition OR definitions)	Title	15
Snowballing	-	-	9
Total			188

* Web of Science*, DOAJ* and DBLP* allow meta-data searching rather than in the full text

** Google Scholar does not provide searching in meta-data except specific to title

A basic test was applied to examine whether the studies covered after the snowballing process are included or not in our review. Thereby the completeness of the literature review might be evaluated by this test.

Regarding this test, as seen in the "Place" column in Table 2, six of them not detected are due to the item EC2, that is, because they are not peer-reviewed publications. Two of them are not accessible online (EC3). One of them is in a digital library not accessible by the authors (EC3). The remaining four of them are about the digital libraries covered by the authors; one of these three is in a particular database (designsociety.org), one of them is in a database that is not accessible by the authors (IGI-Global), one is in Springer, and the last one is in JSTOR. This result shows that we have succeeded in identifying the relevant studies in all the searched library databases. We are aware that it is very

challenging for us to scan the entire literature and in this sense, we had to proceed with a deliberately selected set of libraries. Additionally, we have accomplished covering many possible definitions in the literature throughout the libraries we have selected. We have come across a new definition from only two libraries (Springer and JSTOR) that we have not intentionally covered.

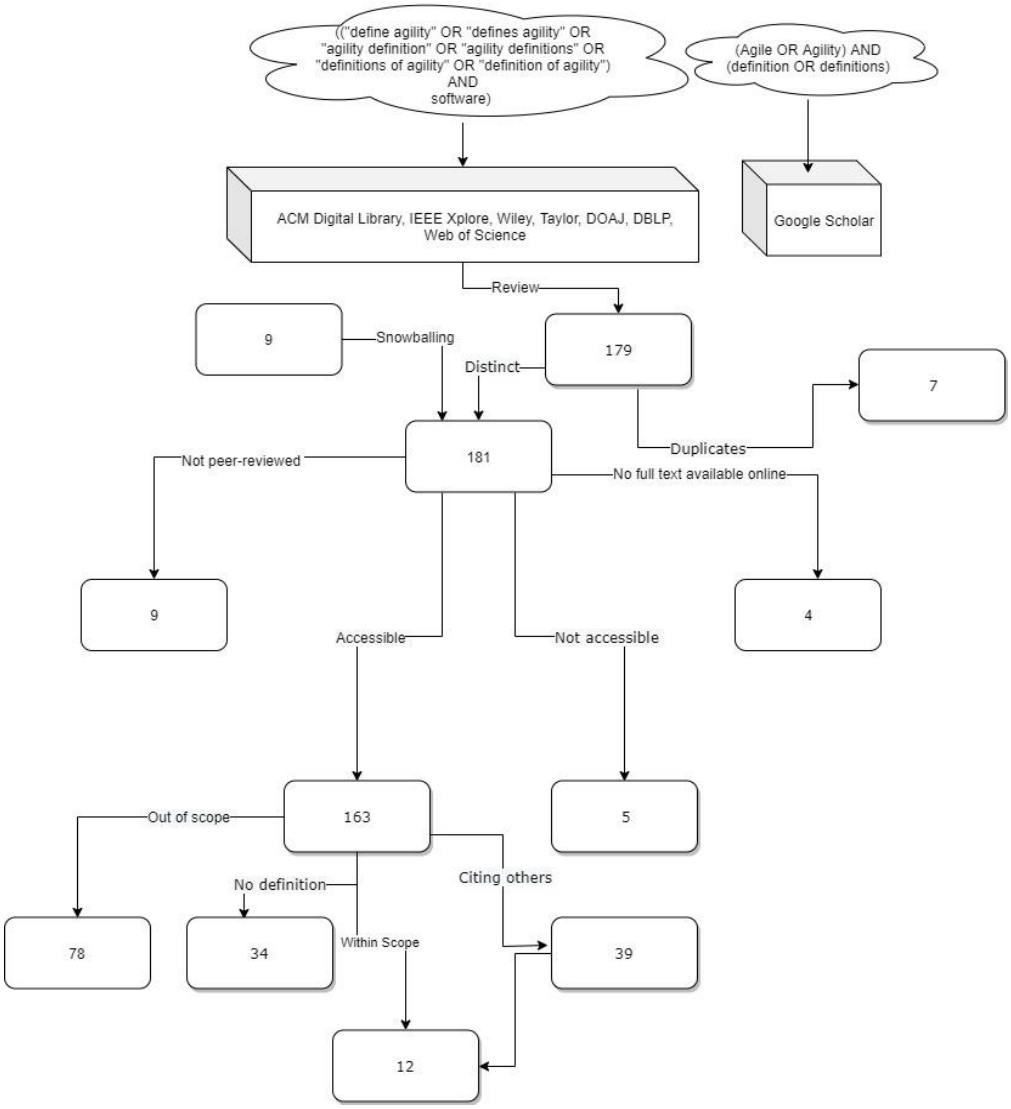

Fig.1. Result for Literature Review on Agility Definitions

The definitions found from the snowballing process are included in our study, even though peer-reviewed publications do not provide them. While especially books resources are likely to contain useful information in our scope, they are unlikely to be systematically reviewed. Although these sources were not systematically reviewed, the encountered definitions provided by them were also found useful and included in our study. Consequently, the contents extracted from relevant studies are presented in Table 2. Definitions in the table are not meant to be exhaustive or comprehensive. However, we deem them adequate to understand and scope the definition.

Despite the diversity in definitions, the software development domain can still learn from research findings in other domains by adopting widely accepted and less context-dependent concepts [7], like agility. Thus, we regard such definitions that are fundamental and domain-independent helpful to the software development domain for the definitions based on domains outside software development or IS/IT, when it is feasible and valuable to mix definitions of such variations. Thereby we covered the mostly encountered definitions of agility other than software development or IS/IT domain, yet not specific to its domain and convenient to include in our study, to propose the universal agility concept. They are indicated as “Agility (General)” terms in the table and mainly from the manufacturing domain. It is a considerably mature domain posing a base for other domains in terms of providing agility definitions. Besides, we found it helpful to include the general and generic dictionary definition of agility that poses generalizable abstraction levels. The definitions should consider and cover the highest level of abstraction provided by the dictionary definition of agility.

Table 2. Existing Definitions of Agility

Domain	#	Source	Place	Definition	Facet(s)
Agility (General)	P1	[32]	-	Ability to expedite	Quick
	P2	[33]	-	The ready ability to fundamentally change states to accommodate unforeseen circumstances in a timely manner.	Continual readiness, timely, unpredicted/unexpected
	P3	[34]	-	To move quickly and easily	Quick and easy
	P4	[35]	-	Constant changes in a team or organization as it evolves in its lifecycle	Constant changes, evolving
	P5	[36]	-	The ability to create and respond to change in order to succeed in an uncertain and turbulent environment.	Create and respond to change, succeeding
	P6	[37]	-	Rapid and flexible response to change.	Rapid, flexible, response
	P7	[19]	-	The ability to create and respond to change.	Responsiveness, create change
	P8	[24]	-	The ability of firms to sense environmental change and respond readily	Sensing, respond, being ready
	P9	[38]	-	Responding to change (anticipated or unexpected) in proper ways and due time.	Responding, anticipated or unexpected change, due time
	P10	[39]	-	Uses feedback to make constant adjustments in a highly collaborative environment	Constant adjustments
	P11	[40]	-	Being gently rolling, light, flexible, witty and nimble.	Light, flexible and nimble
	P12	[41]	-	The effective response to rapid and unexpected change with flexibility, implying adaptability and versatility in the domain to respond to such unexpected changes	Response, rapid and unexpected change, flexibility, adaptability, versatility
IS/IT/Software Development Agility	P13	[42]	Web page	Iterative and incremental (evolutionary) approach to software development which is performed in a highly collaborative manner by self-organizing teams with "just enough" ceremony that produces high-quality software in a cost-effective and timely manner which meets the changing needs of its stakeholders	Quality, cost-effective, timely
	P14	[25]	SLR	Capacity of a system to (i) detect any (potentially unexpected) situation that requires the system to change and (ii) adapt its global structure/behavior to that situation.	Unpredicted/unexpected change, adaptability
	P15	[43]	designsociety.org	Capability to react, and adopt to expected and unexpected changes within a dynamic environment constantly and quickly; and to use those changes (if possible) as an advantage.	Reaction, adaptability, expected and unexpected change, constantly, quick
	P16	[30]	Book	Being effective and maneuverable. Use of light-but-sufficient rules of project behavior and the use of human and communication-oriented rules	Being effective and maneuverable, light
	P17	[23]	SLR	The continual readiness of an information systems development method to rapidly or inherently create change, proactively or reactively embrace change, and learn from change while contributing to perceived customer value (economy, quality, and simplicity), through its collective components and relationships with its environment	Rapidly or inherently, proactively or reactively, customer value, collective components, relationships with environment
	P18	[22]	SLR	The continual readiness of an entity to rapidly or inherently, proactively or reactively, embrace change, through high quality, simplistic, economical components and relationships with its environment	Continual readiness, rapid, inherently, proactively or reactively, embrace change, quality, simplistic
	P19	[44]	SLR	As possible to promote quick response to changing environments, changes in user requirements, accelerated project deadlines, and the like	Responsiveness, quick
	P20	[45]	Springer	Ability to sense and respond to changes in an organization's internal and external environment by quickly assembling resources, relationships and capabilities	Sensing, responsiveness, quick, collective components
	P21	[46]	Book	Information systems development and deployment methods to swiftly adapt to the changing business requirements	Adaptability, quick
	P22	[15]	SLR	Responsiveness to change	Responsiveness
	P23	[47]	Book	Ability of an organization to both create and respond to change in order to profit in a turbulent business environment	Responsiveness, create change, value
	P24	[48]	SLR	Ability to quickly, and at an early stage, build functionality and quality into software	Quick, proactivity,
	P25	[31]	SLR	The ability of an organization to react to changes in its environment faster than the rate of these changes	Reaction, fast
	P26	[49]	Not digital	Ability of the process to successfully cope with changes in requirement	Successful
	P27	[18]	JSTOR	Software team's capability to efficiently and effectively respond to and incorporate user requirement changes during the project life cycle	Responsiveness, efficient, effective, embrace change
	P28	[50]	Book	Ability to 'detect new techniques', and adapt those techniques to the organization	Sensing, adaptability

	P29	[51]	IGI-Global	Agility is concerned with why and how ISD organizations sense and respond swiftly as they develop and maintain information system applications.	Sense and respond
	P30	[52]	Not digital	Ability to respond to changing circumstances where: Ability is characterized by readiness and speed of action. Response is: (1) Making use of an existing configuration (by internal means), (2) By reconfiguration (facilitated by external means). Changing circumstances may be: (1) A change in objective, (2) A change in environment, (3) A change in condition. Agility is measured by: (1) Speed of action, (2) Cost in resource, (3) Impact on effectiveness	Responsiveness, continual readiness, speed, flexibility, reconfiguration, cost-effective, effectiveness
	P31	[53]	SLR	Ability of IT artifacts, of information stored within those artifacts, and of the underlying processes that support and maintain the artifacts and information to quickly adapt to changing business need	Adaptability, quick
	P32	[90]	SLR	Ability to continuously adapt to its complex, future and solution focused needs	Constantly, adaptability, proactivity
	P33	[54]	SLR	Ability to move quickly and easily, to adapt to changes of the reality or to create changes becoming the reality, let us say in the domain of software solution development.	Quick, easy, adaptability, create change
	P34	[29]	SLR	A persistent behavior or ability of a sensitive entity that exhibits flexibility to accommodate expected or unexpected changes rapidly, follows the shortest time span, uses economical, simple and quality instruments in a dynamic environment and applies updated prior knowledge and experience to learn from the internal and external environment	Flexibility, speed, leanness, learning and responsiveness, persistent behavior
	P35	[55]	Book	Building software by empowering and trusting people. Acknowledging change as a norm, and promoting constant feedback. Producing more valuable functionality faster.	Change as a norm, value, fast, acknowledging change as a norm
	P36	[56]	SLR	The Information System is agile from the moment it appropriates a set of processes and strategies that involves incrementally the user, to acquire the ability to adapt flexibly to the information system changes and continue to achieve goals, by decreasing response time, despite the pressure and the turbulent in the unpredictable environment	Adaptability, flexibility, successful, decreasing response time

Study [38] argues that a definitive, all-encompassing concept of agility might be found by examining the underlying agility concepts, i.e., flexibility and leanness. Some traits have emerged from our literature review: the dimensions (facets) of agility definitions. Along with the definitions of agility, we then parsed the definitions in terms of the dimensions (facets) as listed in Table 3 that the particular definition provides. In doing so, we ignored the practical parts of those definitions as the practices paving the way to achieving agility (and its definition) can be unlimited. We did not include such parts such as for the item "building software by empowering and trusting people"). Similarly, study [31] argues that the definition of agility should use the ultimate purpose or function of being agile for a business, rather than defining agility by a labeled set of practices. However, if a facet related to a particular practice is clearly and explicitly stated by the author(s) as a facet of the agility definition, then we have included it in our list to make it appear.

These determined facets were then grouped according to their similarities for a further detailed analysis and discussion under the following topics. Thus, a part was dedicated to some facets to reveal the interrelated concepts with and indispensable for agility definition (and therefore often used interchangeably). The development of the definition and conceptualization of agility were then based on this grouping. Table 3 lists these grouped items. For the groups including more than one word in the same line, (a) representative(s) (more well-known ones among the others) concept(s) was/were chosen to represent the group in the further referring and are discussed either with a dedicated subsection or as a content inside the relevant subsections (those facets are indicated as boldface in the content).

Table 3. Group of Facets

Group of Facets	**Description**	**Representing Term**	**Sources**	**Number of Papers**
Quick, Rapid, Speed, Fast, Timely, Due time, Decreasing response time	Time dimension of agility process	Rapidity	P1, P2, P3, P6, P9, P12, P13, P15, P17, P18, P19, P20, P21, P24, P25, P30, P31, P33, P34, P35, P36	21
Responsiveness	Delivering response as output of the agility process. Can be proactive, reactive, null or non-null output to external or internal environment.	Responsiveness	P5, P6, P7, P8, P9, P12, P19, P20, P22, P23, P27, P29, P30, P34	14
Easy, Inherently, Maneuverable, Change as a norm, Continual readiness, Being ready, Nimble, Constantly, Persistent behavior	To expresses agility as a feature of natural, default, easy not an extreme, occasional and challenging state.	Inherently	P2, P3, P4, P8, P11, P15, P16, P17, P18, P30, P32, P33, P34, P35	14

Adaptability, Reconfiguration, Adjustment	Unlike responsiveness, focuses on the inward change of the entity, not on the response to outward.	Adaptability	P10, P12, P14, P15, P21, P28, P30, P31, P32, P33, P36	11
Effectiveness, Succeeding, Successful, Value	Represents producing the expected output. Since the quality of the output is proportional to the quality of the input, naturally includes the input qualifications.	Effectiveness	P5, P16, P17, P23, P26, P27, P30, P35, P36	9
Proactivity, Create change	Represents the actions triggered by an internal stimulus before the change takes place, without the need for an external stimulus.	Proactivity	P5, P7, P17, P18, P23, P24, P32, P33	8
Flexibility, Versatility	Similar to adaptability, reconfiguration and adjustment, focuses on the inward change of the entity, not on the response to outward yet different from them, in a predefined and deterministic way.	Flexibility	P6, P11, P12, P30, P34, P36	6
Anticipated, unpredicted/unexpected, constant and rapid change	Lists kinds of inputs subjected to agility process	Change	P2, P9, P12, P14, P15	5
Reactively, Reaction	A kind of responsiveness, yet a passive position in its nature	Reaction	P15, P17, P18, P25	4
Sensing	Detecting internal and external stimulus	Sensing	P8, P20, P28, P29	4
Light, Simplistic	As a feature that comes from Agile methods, attributed to the methods that are easy to understand but difficult to implement.	Simplicity	P11, P16, P18	3
Cost-effective, efficient	About how much fuel the agility process consumes. Has a linear structure.	Efficient	P13, P27, P30	3
Embrace change, Acknowledging change as a norm	The general expression of positive attitude towards change after sense and diagnosing of change.	Embrace change	P18, P27, P35	3
Quality	Expresses quality concept in its known sense	Quality	P13, P18	2
Collective components	Represents the sub-components that make up the entity acting in harmony, alignment, collectively and with a specific purpose throughout the agility process	Collective components	P17, P20	2
Relationships with environment	Means being in communication with the environment due to the nature of the change.	Relationships with environment	P17	1
Leanness	Especially inspired from production systems, a concept that aims to reduce waste and increase optimization. Lean processes don't have to be simple or lightweight; therefore, they are separate items in the table. (While leanness can be high in complex systems (e.g. cars, planes), waste can be high even in simple processes).	Leanness	P34	1
Learning	Refers to continuous learning to improve the agility process and its output.	Learning	P34	1
Evolving	To change or develop gradually	Evolving	P4	1

5. Related Concepts with Agility

Content validity is closely dependent on a careful definition of a construct, including distinguishing it from related concepts [57] and their meaning boundaries. The lack of clarity in explaining the interrelationships among constructs may lead to conflicting conclusions [58]. Thus, in this section, we will examine and discuss the prominent facets determined in Table 3 related to agility, especially to reveal their differences, similarities, and relationships with agility by specifying not only what it is but also what it is not. This clarification will form the basis for and lead to our proposed definitions of agility. Among the facets, those open to the discussion were given a particular title below. Along these facets under dedicated titles, relative yet partially transparent concepts were also covered and marked bold under the corresponding titles. The literature review indicates inconsistency and ambiguity regarding the use of the responsiveness, agility, and flexibility constructs. Therefore, it is unclear whether agility, flexibility, and responsiveness are synonyms or distinct [33]; thus, we have given more space to distinguish them properly.

5.1. Flexibility

The literature shows that the content of the terms ‘flexibility’ and ‘agility’ have overlapping notions, which implies the interchangeable use of these terms [7]. Both agility and flexibility present organizations' ability to respond to changes in the environment, yet with different characteristics. However, confusing agility with flexibility seems to be a

common mistake [1].

The most noticeable distinction between the two is that the **time aspect** has an emphasis on agility. Flexibility is the general ability to react to changes [59], while agility is related to quickness in responding to variety and changes [60]. Therefore, being agile presupposes being time-sensitive that inheres in agility, which differentiates agility from flexibility [1].

According to Wadhwa and Rao [10], change in flexibility can be of two types: stochastic (uncertainty related) and deterministic (certainty related). This indicates that flexibility is for responses with scheduled or planned adaptation to unforeseen yet **predictable** and **expected** external circumstance changes and agility entailed for an unplanned and unscheduled yet innovative response to unforeseen, **unpredictable** and **unexpected** circumstances [10, 61]. While flexibility responds with a system's ability to change status for known situations with previously established procedures and within existing configurations (with pre-established parameters), agility is viewed as an extension of flexibility; agility allows the entity to respond to unpredictable changes [33, 62], with systems' ability to rapidly re-configure [33]. Hence, study [33] argues that agility is more than just 'flexibility' and subsumes or is supported by flexibility.

Flexibility is not a case of continual vigilance; instead, the entity deterministically and with its predefined configuration setup is prepared for the change upfront. Agility on the other hand is viewed as the approach for a rapid re-configuration of a system when faced with unpredictable changes [33], making flexibility more deterministic and agility non-deterministic. Facing unexpected circumstances takes agility to a position with **continual readiness** and awareness to **adjust** to change [63], pushing agility to behave naturally and effortlessly (referring to the items such as **easy, inherently, change as a norm**, **being ready**) and **efficiently**.

Intrinsic and internal characteristic of flexibility also implies that the place of change is inside the entity itself. However, in agility, the entity interacts with its environment in a mutual way to change the environment if required. This distinction also takes us to another difference in terms of the area in which the change is created. In contrast, the change in **flexibility, adaptability, reconfiguration** and **adjustment** is inside the entity. The agility change may refer to a change inside the entity or its environmental relationships. It sets forth the fact that "an entity may not be a closed system, rather it may interact with other systems in its environment and may be able to use these interactions to handle change" [22].

From the viewpoint inside the entity, the term "flexibility" implies that the entity is homeostatic [23] within deterministically predefined configurations in the face of change. However, not only can an entity try to shape into its pre-defined state when a change happens or may occur (as with flexibility), but the entity may t**ake advantage of the change** to take itself in a better position that is not inherently pre-defined in advance (as with agility) to maximize and capitalize the potential benefit from the change. This is also the main reason why the entity **embraces** and welcomes the change as a positive input.

Additionally, the entities can be the primary instigators of change. They can trigger themselves for a change ending an improved position (such as in self-improvement and proactive approaches) in the agility context. Unlike one that is usually passive and only subjected to change that originates outside of the entity, which is the usual case with flexibility. Pro-action is where the entity takes actions to elicit changes before they occur, such as prototyping [22].

Lastly, agility is not a simple summing of the **components**; rather, it depends on their nonlinear relationship [50], calling for the sub-components acting in harmony, alignment, collectively, and with a specific purpose throughout the agility process. Thus, the sub-components relationship brings additional complexity to the entity (especially at the run time), not a typical case for flexibility.

5.2. Responsiveness

We see "responding to change" as the widely recommended feature of agility. Study [33] defines responsiveness as the system's actual and purposeful change in behavior or outcome (in the external side) caused by a stimulus. Responsiveness is defined by Barclay and Dann [83] as "reacting purposefully and within an appropriate timescale". Kruchten [31] defines agility as "the ability of an organization to react to changes in its environment faster than the rate of these changes". While the definitions of responsiveness and **reaction** look alike and seem close to a possible agility definition, we prefer to use "responding" as a better reflection of agility than "reaction to" in describing it. Reaction-based agility definitions take us to a passive position of re-acting. Although IS/IT has traditionally taken a passive position throughout its history as it has been seen as a business-driven body, it is not a standard rule beyond ages [54].

As well as using agility to react to change in an after-the-fact behavior, even software development agility should permit an entity to instigate and create a change, **proactively**, in advance of the change. The concept of responsiveness indicates that an entity can take some active steps (offensive mode) or embrace change by taking no action (defensive mode). As well as having a passive mode to manage changes, agility can additionally be used proactively to anticipate and act to create a change in advance of change proactively. While the term "**adaptation**" suggests that the driving force is change and the entity's actions result from that force [22], agility indicates a two-way process covering reacting to change and influencing it by creating changes. Proactive activities, if done well, should thus reduce the need to react. Therefore, the less reaction required, the higher the level of robustness achieved [22].

5.3 Rapidity

Throughout the agility process, the time dimension should be the central criterion to evaluating the entity's agility, from low to high level. Agility is not a binary state of "being agile" or "not being agile". Several intermediate states (shades of grey) do exist [82] in terms of time frame, which makes responding both in a year or a couple of days agile, at different degrees for a specific event. Since time is such a key criterion for determining and evaluating the degree of the entity's agility, it is imperative to involve it in the definitions.

In line with this view, according to our literature review and Conboy [23], the term rapid (along with speed, quick, and fast) takes place in most definitions of agility. The majority of the studies already indicate the time aspect as a primary agility attribute. However, some of the studies indicate speed as a primary measure of agility. For instance, Gren and Lenberg [15] argue that the temporal dimension that agility calls for is speed as necessary in the Agile space. In parallel, study [87] puts forward that the concept of quickness and speed is at the heart of agility. However, Conboy and Fitzgerald [22] have emphasized rapidity instead of speed in the definition of agility. We agree with this choice because speed has a linear characteristic while rapidity is more suited to represent the versatility and diversity required for agility; moving fast without an appropriate timescale, e.g., using a long way, is not agile by definition.

The temporal dimension of agility must naturally include the notion of time taken by the entity to **sense**, determine what action to take, and carry out that action. Quick and accurate sensing (detecting and anticipating) [24, 25] and its relevance is critical to agility [25]. However, speed alone should not be considered a success measure [22]. According to Aoyama [81], Agile Software Development does not merely mean rapid application development. Instead, it emphasizes rapid and flexible adaptation to changes in the process, product and environment. Volberda [80] also acknowledges the value of the change by comparing large or strategic valuable change with a slow response to rapid response to a familiar change.

5.4 Leanness

Studies have a hard time distinguishing between agile and lean [74]. The core of lean relates to **efficiency** (i.e. doing things right), which is about removing waste while sustaining the same productivity [75]. Leanness focuses on "the reduction and elimination of waste" [76, 77] and "doing more with less" [78, 79]. Leanness aims to approach the zero (waste) point. Agility, however, leans more on the expansion of perspectives; learning (fail fast), creating some features only to understand customers better at the earliest, costly cross-functional teams in agile to produce time-effective responses. Therefore, agility is not about improving efficiency or cutting costs [63]. This "haste" to respond quickly in agility may "make waste", implying that leanness and agility approaches can be contrasted serving in two different directions. Therefore, we disagree with the definition of "dealing with change while minimizing the cost" in the agile approach, as proposed by Conboy and Fitzgerald [22]. However, some agile development ideas are shared with Lean Thinking [17]. Agile has a lean perspective by advocating just enough documentation, reducing "ineffective communication" occurring mainly in the hierarchy, tools, and processes. This leanness saves time by preventing the waste of time by removing unnecessary steps in processes where agility is needed and supports agility in this sense. Hence, lean and agile approaches are used together somehow, yet with some confusions and contradictions.

Simplicity forms a key tenet of lean thinking [23]. However, Lean systems do not necessarily have to be simple, and sometimes, it is not possible to be so. For example, every part in an airplane or mechanic clock representing a complicated system has a role. It cannot be possible to find a point in the name of waste, which is enough to call it "lean" by definition. Then, it would be misleading to state that such complicated yet lean systems are simple. Therefore, these two concepts stand as separate items in the table and throughout this study.

5.5 Simplicity

Agile systems to manage complex systems do not bear inherent simplicity inside. Appelo [64] and Leffingwell [65] state that agile is context-specific depending on complexity theory. With simple systems, it is only possible to manage complexity with a low-level degree of agility. Study [66] notes that "the very name agile suggests that the method should be easily adjusted to suit its environment", making the agile system itself complex, not simple. Appelo [64] notes that most people misunderstand agility because they have not understood complexity theories from which agile originates. According to him, any simplistic, linear model (that poses predictability somehow) is bound to fail. For example, with Scrum, which refers to itself as "simple", it is claimed that agility is not guaranteed by applying it, even fully [67], and even more, the real agility does not come to light in the constraints of such methods [68]. Adolph [69] stresses that agility depends on organizational culture and climate rather than tools and processes. This cultural dependency makes agility complex enough beyond far from simplicity. Although some people claim a link between agility and simplicity regarding simplicity as an agility provider, few studies prove this assertion.

5.6 Quality

Some client constraints (such as unstable requirements as in Agile) were considered obstacles in developing software with quality [70], especially within tight and rigid deadlines in Agile [93]. Conboy and Fitzgerald [22] argue that dealing with change leads to diminished quality. Similarly, study [71] reports cases in which Agile harms quality

mainly due to the stress of time inherited in agility. In this manner, agility and quality are two separate and sometimes opposite concepts that pull in different directions instead of gains in the same direction. For instance, Gren and Lenberg [15] propose quality as a force against agility to balance it. Systems with high quality are expected to be more agile, but agile systems do not assure, even inhabit, to produce better quality results.

5.7 Learning

According to study [72], an agile entity improves over time as it gains experience and knowledge from its internal and external environment. Boehm and Turner [73] assert that "agility applies memory and history to adjust to new environments, react and adapt, take advantage of unexpected opportunities, and update the experience base for future". "Updating the experience base for future" happens in almost all areas like in quality management.

5.8. Effectiveness

Theoretically, the initial triggering change does not have a role beyond being a trigger in the agility process. To clear up this assertion, let us consider these questions:

- Is it agility to respond rightly to wrong (not valuable) change?
- Is it agility to react wrongly to the correct change?

Contrary to common belief, the answer to the first question may be yes (regarding the degree of the relevance of the response). Agility acts when the process is triggered, and it does not necessarily question the qualifications of the inputs. It is similar to the product backlog list prioritized (inputs) and presented by the product owner in Scrum to the development team. The value of change itself is not an argument that can be handled exclusively within agility. Even in a ship set for the exploration of the continent of America, it is very likely to respond to the changes pushing it to India, which is, of course, sufficient to call it agile. From another point of view, if something (value generation) can be happening without any change (management), it may not be necessarily related, at least directly, to agility. In the same vein, why should the process for a cheetah to choose its prey (development project) be agile. In other words, responding to changes and identifying valuable changes are two aspects needed to be considered separately.

Contrary to what is generally known regarding the second question, the agility process does not guarantee producing and delivering the proper response to the change. This means that there is no inherited assurance mechanism in the process for it. No devotion beyond what a usual process inherently bears for this concern regarding producing the correct result or being effective, successful or valuable, is also valid for the agility process mainly. Conversely, it is suggested that agility be balanced with other stabilizing factors so that it does not become dizzy due to its focus on change-orientation and does not sacrifice other factors despite the speed. (Right) value must have priority over speed, and factors such as quality as a force against agility to balance it should be in place [3]. Study [54] reports that agile adaptation without a balance can damage quality, enterprise-wide, risk-driven, systematic, realistic approaches, and satisfactory inspection. They add that it may lead to the emergence of unsustainable structures that will not benefit the customers in the long run and to the teams resulting in isolation, moving away from the holistic picture with adaptation pressure. Consequently, agility indicates a means to enable (not to guarantee or ensure with a commitment) specific (not a whole) aspects of a desirable outcome rather than an end in itself.

5.9. Evolving

The output of the agility process can be another input to another agility process or itself. This successive nested relationship of the processes allows for iterative and incremental growth called gradual development. However, since this situation is optional, it does not have to be within the definition of agility.

6. Discussion

6.1 Discussion of the Existing Definitions

Table 4 lists the identified negative and positive sides of existing definitions based on the discussion and distinction of the concepts above. The negative sides include 28 different items. As discussed previously, passive mode represents only one side of agility. After seeing the differences between flexibility and agility, we can say that attributing agility to solely flexibility is not correct. While there are numerous ways of achieving agility, it is erroneous to put certain practices in the definition (consider an organization having self-organization teams and still following a traditional process). According to Gren and Lenberg [15], some people often interpret agile as a set of practices and ignore essential factors. Including items in the definitions, such as quality, conflicting concepts with agility, does not make agility definitions better. We have seen that some definitions focus only on the input side, and some solely on the output side of the process. Although agility should not be limited only to specific environmental contexts (such as a dynamic or turbulent environment), it is observed that some definitions have contextual reductions to specific environments in their definitions. Certain degrees of changes may be experienced within many different contexts

bearing varying characters, and agility may become a natural requirement of such environments. Another handicap of such a limitation in determining the threshold of a dynamic or turbulent environment is about how to determine the threshold. As discussed, agility does not guarantee the right results, high value, or success. In some definitions, agility's main essential items, like the time aspect, are not covered. The minority of the studies define agility by comparing it to waterfall-like development methods. According to Gren and Lenberg [15], it is cumbersome and misleading to define a concept only by contrasting it to something else.

Considering the positive sides, a proper definition of agility should involve time dimension, all types of changes (expected, predicted, unexpected and unpredicted), responses (proactive, reactive, from inner and outer), all types of realization, including sensing and operating the agility process as a norm, easily, continually, persistently and inherently. The definitions should inherit the dictionary definition features, which is the most generic definition; "to move quickly and easily". Therefore, the positive sides include ten different items, as shown in Table 4.

Table 4. Negative and Positive Sides of Definitions

#	**Definitions**	**Negative Sides**	**Positive Sides**
P1	Ability to expedite	Only includes the time dimension	-
P2	The ready ability to fundamentally change states to accommodate unforeseen circumstances in a timely manner.	Not all change types covered, changing states is used equivalent to flexibility.	Rapid, unexpected change, being ready
P3	To move quickly and easily	Very generic definition	Quickly and easily
P4	Constant changes in a team or organization as it evolves in its lifecycle	Not all change types covered, there is no dimension of time, covers only limited dimension of the agility process	-
P5	The ability to create and respond to change in order to succeed in an uncertain and turbulent environment.	The definition of the environment from which the change originates may not cover all types, there is no dimension of time, agility does not guarantee the right results	Including both proactive and reactive response types
P6	Rapid and flexible response to change.	Passive mode, attaching agility solely to flexibility	-
P7	The ability to create and respond to change.	There is no dimension of time	Including both proactive and reactive response types
P8	The ability of firms to sense environmental change and respond readily	The entity is not software development specific, not all change types covered, covers only limited part of the agility process	Responding, being ready
P9	Responding to change (anticipated or unexpected) in proper ways and due time.	Passive mode, "in proper ways" is too generic term	-
P10	Uses feedback to make constant adjustments in a highly collaborative environment	Covers how sides, there is no dimension of time, adjustment is used equivalent to flexibility.	-
P11	Being gently rolling, light, flexible, witty and nimble.	Being light is not a basic requirement for agility, provided with an antithesis, recursive definition (agility is agility).	-
P12	The effective response to rapid and unexpected change with flexibility, implying adaptability and versatility in the domain to respond to such unexpected changes	Covers how sides, there is no dimension of time, adjustment is used equivalent to flexibility.	-
P13	Iterative and incremental (evolutionary) approach to software development which is performed in a highly collaborative manner by self-organizing teams with “just enough” ceremony that produces high-quality software in a cost-effective and timely manner which meets the changing needs of its stakeholders	Agility does not guarantee the right results, almost all of the definition is about how.	-
P14	Capacity of a system to (i) detect any (potentially unexpected) situation that requires the system to change and (ii) adapt its global structure/behavior to that situation.	Adaptation oriented, not all change types covered,	"Potentially" statement indicates proactivity
P15	Capability to react, and adopt to expected and unexpected changes within a dynamic environment constantly and quickly; and to use those changes (if possible) as an advantage.	Passive mode, adaptation oriented, Agility does not guarantee the right results, the definition of the environment from which the change originates may not cover all types	"if possible" statement indicates no obligation
P16	Being effective and maneuverable. Use of light-but-sufficient rules of project behavior and the use of human and communication-oriented rules	Agility does not guarantee the right results, almost all of the definition is about how	-

P17	The continual readiness of an information systems development method to rapidly or inherently create change, proactively or reactively embrace change, and learn from change while contributing to perceived customer value (economy, quality, and simplicity), through its collective components and relationships with its environment	Covers how part, includes the conflicting concepts that are difficult to be with agility together, covers only limited part of the agility process (not delivering side)	Continual readiness, to rapidly or inherently create change, including both proactive and reactive response types, embracing change
P18	The continual readiness of an entity to rapidly or inherently, proactively or reactively, embrace change, through high quality, simplistic, economical components and relationships with its environment	Covers how part, includes the conflicting concepts that are difficult to be with agility together, covers only limited part of the agility process (not delivering side)	-
P19	As possible to promote quick response to changing environments, changes in user requirements, accelerated project deadlines, and the like	Not all change types covered	"Quick response" statement
P20	Ability to sense and respond to changes in an organization's internal and external environment by quickly assembling resources, relationships and capabilities	The agility process may not produce an output only through these activities.	"Quick response" statement, covering both internal and external sides
P21	Information systems development and deployment methods to swiftly adapt to the changing business requirements	Adaptation oriented, not all change types covered, limited entity types	"Swiftly" statement
P22	Responsiveness to change	Passive mode, there is no dimension of time	"Responsiveness" statement
P23	Ability of an organization to both create and respond to change in order to profit in a turbulent business environment	Agility does not guarantee the right results, the definition of the environment from which the change originates may not cover all types	Including both proactive and reactive response types
P24	Ability to quickly, and at an early stage, build functionality and quality into software	Not change oriented, very narrow definition	-
P25	The ability of an organization to react to changes in its environment faster than the rate of these changes	Passive mode, the correlation between input and output doesn't have to be this way	-
P26	Ability of the process to successfully cope with changes in requirement	Very generic definition	-
P27	Software team's capability to efficiently and effectively respond to and incorporate user requirement changes during the project life cycle	Not change oriented, limited entity types, very narrow definition, covers only limited part of the agility process (only the output part), not all change types covered, there is no dimension of time	-
P28	Ability to 'detect new techniques', and adapt those techniques to the organization	There is no dimension of time, adaptation oriented, not all change types covered	-
P29	Agility is concerned with why and how ISD organizations sense and respond swiftly as they develop and maintain information system applications.	-	Sensing, responding
P30	Ability to respond to changing circumstances where: Ability is characterized by readiness and speed of action. Response is: (1) Making use of an existing configuration (by internal means), (2) By reconfiguration (facilitated by external means). Changing circumstances may be: (1) A change in objective, (2) A change in environment, (3) A change in condition. Agility is measured by: (1) Speed of action, (2) Cost in resource, (3) Impact on effectiveness	Covers only limited dimension of the agility process (only the output part of the process), using speed rather than quickness, attaching agility to flexibility, reconfiguration is not necessarily facilitated by external means, Agility does not guarantee the right results	"Respond to changing circumstances" statement covers most of the variations, "readiness" statement
P31	Ability of IT artifacts, of information stored within those artifacts, and of the underlying processes that support and maintain the artifacts and information to quickly adapt to changing business need	Not all change types covered, limited entity types, adaption oriented	-
P32	Ability to continuously adapt to its complex, future and solution focused needs	Not all change types covered, adaptation oriented, there is no dimension of time, covers only limited part of the agility process	-
P33	Ability to move quickly and easily, to adapt to changes of the reality or to create changes becoming the reality, let us say in the domain of software solution development.	Adaptation oriented, not all change types covered, "move" statement is so generic term, Agility does not guarantee the right results	Including both proactive and reactive response types, "quickly and easily" statement
P34	A persistent behavior or ability of a sensitive entity that exhibits flexibility to accommodate expected or unexpected changes rapidly, follows the shortest time span, uses economical, simple and quality instruments in a dynamic environment and applies updated prior knowledge and experience to learn from the internal and external environment	Covers the how part, includes the conflicting concepts that are difficult to be with agility together, attaching agility solely to flexibility, the definition of the environment from which the change originates may not cover all types	Persistent behavior, sensing

P35	Building software by empowering and trusting people. Acknowledging change as a norm, and promoting constant feedback. Producing more valuable functionality faster.	Agility does not guarantee the right results, the rest of the definition is about how, essential main items of agility not covered,	Acknowledging change as a norm
P36	The Information System is agile from the moment it appropriates a set of processes and strategies that involves incrementally the user, to acquire the ability to adapt flexibly to the information system changes and continue to achieve goals, by decreasing response time, despite the pressure and the turbulent in the unpredictable environment	Attaching agility solely to flexibility, Agility does not guarantee the right results, the definition of the environment from which the change originates may not cover all types, covers how part	-

6.2 Towards a More Overarching Definition of Agility

Evidently, the connotations of the current definitions of agility are still not sufficient, which leads us to propose a more overarching definition of agility in the software development domain that has been developed in light of the considerations made in section 5.

Regarding the "must-parts" of the prospective definition, the definition should cover it throughout when considering the agility process. The first step in the process is the sensing part, making the sensing statement prerequisite for the definition. The changes to sense might include predicted, unpredicted, certain, uncertain, rapid, moderate, external and internal changes. The kind of environments producing those changes should not be necessarily turbulent, constantly changing, fast-paced or such. Environments that do not have these characteristics can naturally produce all kinds of changes listed. Embracing and acknowledging change as a norm should be the nature of agility supported by the entity's inherently easy abilities and agility processes. Then, the internal activities dealing with the change (the “how” part aforementioned) can vary, and this step may be sufficiently complex in itself. To represent delivering the output step, among the candidate terms including Responsiveness, Adaptability, Reconfiguration, Adjustment, Flexibility, Versatility, we prefer to use Responsiveness as it, being more encompassing, meets the relevant process step and other related terms. Despite the widely adopted passive stance, agility should also meet the active stance and include proactive behaviors in it. Across the whole process, regarding the time dimension indispensable for agility, we prefer to use “promptly” representing the whole bunch of the relevant terms.

Regarding the “should-parts”, Leanness, Light, Simplistic, and Quality are not the essential parts of the definition. They can be related to or even conflicting with agility yet as a separate concept, at best. The dimension of effectiveness in the definition is a subject open to discussion. We have seen that this issue has not been discussed enough in the literature we have examined. Nevertheless, as a result of the argument, we made earlier, we do not see the necessity for this concept to be within agility's essential definition. We think it has been subsequently injected into the agility definitions by those who suggest it for different reasons. When it comes to Learning and Evolving, we regard them as optional and not mandatory for all cases, then not to be included in the definition.

Therefore, we propose the following refined definition of agility in the context of software development which reflects considerations of the aforementioned negative and positive sides; “the ability of software development entities including processes, people, technology, tools and approaches to sense and embrace predicted, unpredicted, certain, uncertain external and internal changes, and responding to them reactively or proactively in a timely and inherently manner”.

It is noted that the agility process is convenient to be generically outlined. There are a few aspects that lead this process to variations. One of them is the changes taken as the inputs. These changes can be significantly varying, and it is impossible to list them individually. However, it is possible to list the categories of these changes instead. Another point of variation is the flows in the entity's internal processes to evaluate and decide the change and prepare for the response. The flow paths can also vary significantly, including the subcomponents, their practices, and the dynamic functions. Thus, it goes beyond the limits of being included in the definition. Lastly, the output given as a response may be unpredictable, so it is only possible to define it as a "response". Therefore, the definition we come across has evolved towards a generic definition for agility, and only the types of entities that indicate the context remain specific. On the other hand, this is the main reason why the definition remains relatively generic.

7. Conclusion and Limitations

For a remarkable time, agility has been in the software development industry [91] reaching a wide adoption today [92]. The main arguments and discoveries of this study are as follows; although agility has a remarkable root in the software development domain, even the definition phase, supposed to be one of its first phases, is debatable. We have seen that there are other concepts that are close to agility but are used interchangeably. In particular, it is common to confuse flexibility with agility. On the other hand, it is another confusion that some researchers define agility over the concepts of simplicity and lean thinking, although there is no other apparent unifying factor in their origins except their historical co-occurrence. The reasons why simplicity, which is not inherent in complex systems, has been incorporated into the definition of agility needs further reasoning. In addition, we have seen that there are practices embedded into the agility definitions by some researchers mostly from the manifesto and Scrum. It may probably be due to the fact that

the theoretical knowledge on agility is behind its practical knowledge. However, this situation reduces the definitions that are supposed to be conceptually broad to a narrow scope of the practical level.

Moreover, from our work and the works of Laanti [17] and Gren and Lenberg [15] in particular, we confirm the apparent confusion on the definition of agility in the software development context. To define software development agility, the challenges can be diverse. As one of them, due to its nature, agility is a concept that is hard to define [89]. It seems as a word so broadly used that its meaning has been overly inflated [88], and the broadening of the concept of agility has made it harder to define [12]. Agility is a very seductive, vague, and elusive word, evoking confusion with immediate and personal definitions for almost everyone, leading us to multiple meanings of it [9, 16, 19, 79, 84]. Today's meaning of agility in software development was adopted independently [6] and differs significantly from the dictionary definitions and the ones used before its adoption by the software engineering industry [85]. This indicates that the software development domain has proposed a different meaning to the phenomenon of agility by giving its definitions, which poses a research gap. Lastly, theoretical knowledge on agility is behind its practical knowledge [19], resulting in a lack of knowledge on the academic literature side. All this implies that the endeavor to define agility is still a viable need and attempt for software development. As an instance of such an attempt, we aimed to ratify the definition of the agility concept even though it is an insurmountable task. We are aware that agreeing on a definition is a valuable exercise and a good starting point for a proper understanding of Agility [86] and a better understanding of the phenomenon could enable and lead to more realistic implementations, less disappointment and disillusionment, and possibly greater success rates [19]. In this regard, our study combines, synthesizes and analyzes the current definitions then, after investigating the positive and negative sides of the current definitions, an overarching definition has been proposed.

We are also aware that the concept of agility is complex and multidimensional (i.e. not simply about responsiveness to changes) [6]. It conceals many facets, the definitions of it vary considerably. Regarding these aspects, in this research, various definitions of agility were gathered through a literature review. The facets that the definitions suggest were identified and discussed separately to bring the concept to a higher level of abstraction, then synthesized to create a new yet more comprehensive definition revealing the agility characteristics properly. Other concepts that seem close to agility were addressed in the way amenable to differentiation. In our definition of agility, as initially intended, we have preferably ended up with bringing the concept to a higher level of abstraction that has resulted in extending the breadth of the concept and reducing its properties. Hopefully, this approach facilitates our proposed definition's traveling ability and its applicability to a wide range of heterogeneous contexts.

As Laanti [17] mentioned, agility in software development is an abstract concept, and it will likely take time to be fully understood. We hope our study serves as a stepping stone for this understanding and shortens the time required for it. Moreover, through the evaluations and definition outlined in this paper, we believe that it can help practitioners and researchers to understand, apperceive, and evaluate the agility of any agile objects in the software development domain (e.g. methods, frameworks, organizations, systems, processes). Agile has been mostly practice-led and a fashionable management concept [19]. Our study hopefully contributes to theorizing it.

Our study contains all the hereditary limits and thread to the validity of a systematic review study. The procedures used in our study have limitations in several ways. More likely, we may have missed some relevant studies as we did not include all possible libraries. In particular, we have missed studies published in not-peer-reviewed sources, such books, as it is not practically possible to cover them all. There is also a possibility that our search keyword may not address all definitions. A single researcher extracted the data from the studies as a threat to reliability. Regarding the selection of the facets of the definition of agility, why some were eliminated or partially used, although they are mentioned in the literature were based on the literature and author's opinion; a sound methodological support for the decisions is not applied. Generally speaking, even though the proposed method is based on the well-established systematic literature review techniques and Hoon's study [27], it still stays in theory with no experiments provided to prove the validity and efficiency of it yet. In addition, paradoxically, we are aware of throwing the new agility definition to the universe that needs to be justified further.

As an avenue for the future work, we will provide a justification of the identified issue with the current definitions pointed out in this work with empirical data. Then, if needed, we plan to propose a sound update to our proposed definition.

References

[1] H. Yang, P. Antunes, and M. Tate, "Towards a unified conceptualisation of IS agility", IEEE 20th International Conference on Computer Supported Cooperative Work in Design (CSCWD), IEEE, pp. 269-275, 2016.

[2] M. Kalenda, P. Hyna, and B. Rossi, "Scaling agile in large organizations: Practices, challenges, and success factors", Journal of Software: Evolution and Process, Vol. 30, No. 10, 2018.

[3] L. Gren, A. Goldman, and C. Jacobsson, "Agile ways of working: a team maturity perspective", Journal of Software: Evolution and Process, Vol.32, No.6, e2244, 2020.

[4] E. C. Conforto, D. C. Amaral, S. L. da Silva, A. Di Felippo, and D. S. L. Kamikawachi, "The agility construct on project management theory", International Journal of Project Management, Vol. 34, No.4, pp.660-674, 2016.

[5] P. Kettunen, "Extending software project agility with new product development enterprise agility", Software Process: Improvement and Practice, Vol. 12, No.6, pp.541-548, 2007.
[6] P. Kettunen, and M. Laanti, "Combining agile software projects and large‐scale organizational agility", Software Process: Improvement and Practice, Vol.13, No.2, pp.183-193, 2008.
[7] Y. Gong, and M. Janssen, "Measuring process flexibility and agility", 4th International Conference on Theory and Practice of Electronic Governance, pp.173-182, 2010.
[8] M. Hummel, "State-of-the-art: A systematic literature review on agile information systems development", 47th Hawaii International Conference on System Sciences, IEEE, pp. 4712-4721, 2014.
[9] A. Q. Gill, and B. Henderson-Sellers, "Measuring agility and adaptibility of agile methods: A 4 dimensional analytical tool", The IADIS international conference on applied computing, IADIS Press, 2006.
[10] S. Wadhwa, and K.S. Rao, "Enterprise modeling of supply chains involving multiple entity flows: role of flexibility in enhancing lead time performance", SIC Journal, Vol. 12, No. 1, pp. 5-20, 2003.
[11] A. K., Schirrmacher, and M. Schoop, "Agility in Information Systems-A Literature Review on Terms and Definitions", UKAIS, pp. 25, 2018.
[12] C. Prange, and L. Heracleous (Eds.), *Agility. X: How Organizations Thrive in Unpredictable Times*. Cambridge University Press, 2018.
[13] R. Turner, "Toward Agile systems engineering processes", Crosstalk. The Journal of Defense Software Engineering, pp.11-15, 2007.
[14] N. Abbas, A. M. Gravell, and G. B. Wills, "Historical roots of agile methods: Where did "Agile thinking" come from?", International conference on agile processes and extreme programming in software engineering, Springer, Berlin, Heidelberg, pp. 94-103, 2008.
[15] L. Gren, and P. Lenberg, "Agility is responsiveness to change: An essential definition", Evaluation and Assessment in Software Engineering Conference, pp. 348-353, 2020.
[16] J. Moore, "An ethnography of multiplicity: Wittgenstein and plurality in the organization", 12th Annual International Ethnography Symposium, 2017.
[17] M. Laanti, J. Similä, and P. Abrahamsson, "Definitions of agile software development and agility", European Conference on Software Process Improvement, Springer, Berlin, Heidelberg, pp.247-258, 2013.
[18] G. Lee, and W. Xia, "Toward agile: an integrated analysis of quantitative and qualitative field data on software development agility", MIS quarterly, Vol.34, No.1, pp.87-114, 2010.
[19] D. Ø. Madsen, "The Evolutionary Trajectory of the Agile Concept Viewed from a Management Fashion Perspective", Social Sciences, Vol.9, No.5, pp.69, 2020.
[20] O. McHugh, K. Conboy, and M. Lang, "Agile practices: The impact on trust in software project teams", IEEE Software, Vol.29, No.3, pp.71-76, 2011.
[21] E. Asan,., and S. Bilgen, "Agile Collaborative Systems Engineering ‐ Motivation for a Novel Approach to Systems Engineering", INCOSE international symposium, Vol. 22, No. 1, pp.1746-1760, 2012.
[22] K. Conboy, and B. Fitzgerald, "Toward a conceptual framework of agile methods: a study of agility in different disciplines", 2004 ACM workshop on Interdisciplinary software engineering research, pp. 37-44, 2004.
[23] K. Conboy, "Agility from first principles: Reconstructing the concept of agility in information systems development", Information systems research, Vol. 20, No. 3, pp.329-354, 2009.
[24] E. Overby, A. Bharadwaj, and V. Sambamurthy, "Enterprise agility and the enabling role of information technology", European Journal of Information Systems, Vol.15, No.2, pp.120-131, 2006.
[25] F. Benaben, and F. B. Vernadat, "Information System agility to support collaborative organisations", Enterprise Information Systems, Vol. 11, No. 4, pp. 470-473, 2017.
[26] I. Institute, *21st Century Manufacturing Enterprise Strategy, An Industry-led View*. Iacocca Institute, 1991.
[27] C. Hoon, "Meta-synthesis of qualitative case studies: An approach to theory building", Organizational Research Methods, Vol. 16, No. 4, pp.522-556, 2013.
[28] D. R. Dalton, and C.M. Dalton, "Meta-analyses: Some very good steps toward a bit longer journey", Organ. Res. Methods, Vol. 11, pp.127–147, 2008.
[29] A. Qumer, and B. Henderson-Sellers, "Crystallization of agility: back to basics", 1st International Conference on Software and Data Technologies, Proceedings, 2006.
[30] A. Cockburn, *Agile Software Development.* Addison-Wesley, 2001.
[31] P. Kruchten, "Contextualizing agile software development", Journal of software: Evolution and Process, Vol.25, No.4, pp.351-361, 2011.
[32] D. J. Anderson, *Agile management for software engineering: Applying the theory of constraints for business results*. Prentice Hall Professional, 2003.
[33] E.S. Bernardes, and M.D. Hanna, "A theoretical review of flexibility, agility and responsiveness in the operations management literature: toward a conceptual definition of customer responsiveness", International Journal of Operations and Production Management, Vol. 29, No. 1, pp. 30-53, 2009.
[34] Cambridge, Oxford and Macmillan Dictionaries. Available at: https://dictionary.cambridge.org, https://www.oxfordlearnersdictionaries.com, https://www.macmillandictionary.com
[35] M. Cohn, and K. Rubin, "Comparative Agility", 2007. Available at: http://comparativeagility.com.
[36] https://www.agilealliance.org/agile101/
[37] C. Larman, *Agile and iterative development: a manager's guide*. Addison-Wesley Professional, 2004.
[38] H. Sharifi, and Z. Zhang, "A methodology for achieving agility in manufacturing organisations: An introduction", International journal of production economics, Vol.62, No.1-2, pp.7-22, 1999.

[39] V. Subramaniam, and A. Hunt, *Practices of an agile developer: Working in the real world*. Pragmatic Bookshelf, 2006.
[40] H. Vanharanta, J. Kantola, E. Markopoulos, M. Salo, J. Einolander, and T. Hanhisalo, "The degree of agility in a technology company's strategy, management, and leadership", Management and Production Engineering Review, Vol.9, 2018.
[41] S. P. Wong, and L. Whitman, "Attaining Agility at The Enterprise Level", 4th Annual International Conference on Industrial Engineering Theory, Applications and Practice, San Antonio, 1999.
[42] S.W. Ambler, "Disciplined Agile Software Development: Definition", 2007. Available at: http://www.agilemodeling.com/essays/agileSoftware Development.htm.
[43] A. I. Böhmer, and U. Lindemann, "Open innovation ecosystem: Towards collaborative innovation", 20th International Conference on Engineering Design (ICED 15), Vol 8: Innovation and Creativity, Milan, Italy, pp.031-040, 2015.
[44] J. Erickson, K. Lyytinen, and K. Siau, "Agile modeling, agile software development, and extreme programming: the state of research", Journal of Database Management (JDM), Vol.16, No.4, pp.88-100, 2005.
[45] K. P. Gallagher, and J. L. Worrell, "Organizing IT to promote agility", Information technology and management, Vol.9, No.1, pp.71-88, 2008.
[46] P. Abrahamsson, O. Salo, J. Ronkainen, and J. Warsta, *Agile software development methods: Review and analysis*. Espoo, Finland: VTT publication, 2002.
[47] J. Highsmith, *Agile software development ecosystems*. Addison-Wesley Professional, 2002.
[48] M. Ikoma, M. Ooshima, T. Tanida, M. Oba, and S. Sakai, "Using a validation model to measure the agility of software development in a large software development organization", 31st International Conference on Software Engineering-Companion Volume, IEEE, pp. 91-100, 2009.
[49] T. Kurian, "Agility in IT: Creating Software through Agile Techniques", IEI-International Conference on Agility Design and Manufacturing (ADEMSE-05), Bangalore, India, 2005.
[50] T. W. Lui, G. Piccoli, and K. C. Desouza, "Degrees of agility: implications for information systems design and firm strategy", Agile information systems: Conceptualization, construction, and management, pp.122-133, 2007.
[51] K. Lyytinen, and G. M. Rose, "Information system development agility as organizational learning", European Journal of Information Systems, Vol.15, No.2, pp.183-199, 2006.
[52] T. Mackley, S. Barker, and P. John, "Concepts of agility in network enabled capability", Conference on Networked Enabled Capability, Leeds, UK, 2008.
[53] C. Maurer, "Measuring information systems agility: Construct definition and scale development", Southern Association for Information Systems Conference, pp.155-160, 2010.
[54] N. Ozkan, M. Ş. Gök, and B. Ö. Köse, "Towards a Better Understanding of Agile Mindset by Using Principles of Agile Methods", 15th Conference on Computer Science and Information Systems (FedCSIS), IEEE, pp.721-730, 2020.
[55] P. Schuh, *Integrating agile development in the real world*. Charles River Media Inc., 2004.
[56] F. Z. Tanane, J. Laval, and V. Cheutet, "Towards Assessment of information system agility", 10th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), IEEE, pp. 348-353, 2016.
[57] S. W. O'Leary-Kelly, and R. J. Vokurka, "The empirical assessment of construct validity", Journal of operations management, Vol.16, No.4, pp.387-405, 1998.
[58] E. D. Rosenzweig, and A. V. Roth, "Towards a theory of competitive progression: evidence from high‐tech manufacturing", Production and Operations Management, Vol.13, No.4, pp.354-368, 2004.
[59] L. Li, and X. Zhao, "Enhancing competitive edge through knowledge management in implementing ERP systems. Systems Research and Behavioral Science", The Official Journal of the International Federation for Systems Research, Vol.23, No.2, pp.129-140, 2006.
[60] R. E. McGaughey, "Internet technology: contributing to agility in the twenty‐first century", International Journal of Agile Management Systems, Vol.1, No.1, pp.7-13, 1999.
[61] H. T. Goranson, and T. Goranson, *The agile virtual enterprise: cases, metrics, tools*. Greenwood Publishing Group, 1999.
[62] S. Wadhawa, and K. S. Rao, "Flexibility and agility for enterprise synchronization: knowledge and innovation management towards flexagility", Studies in Informatics and Control, Vol.12, No.2, pp.111-128, 2003.
[63] S. Goldman, R. Nagel, K. Preiss, *Agile Competitors and Virtual Organisations. Strategies for Enriching the Customer*. New York, NY: Von Nostrand Reinhold, 1995.
[64] J. Appelo, *Management 3.0. Leading Agile Developers, Developing Agile Leaders*. Addison-Wesley, 2011. ISBN-10: 0-321-71247-1, ISBN-13: 978-0-321-71247-9.
[65] D. Leffingwell, *Agile Software Requirements. In: Lean Requirements Practices for Teams, Programs, and the Enterprise*. Addison-Wesley, 2011. ISBN-10: 0-321-63584-1
[66] K. Conboy, and B. Fitzgerald, "The views of experts on the current state of agile method tailoring", IFIP International Working Conference on Organizational Dynamics of Technology-Based Innovation, Springer, Boston, MA, pp. 217-234, 2007.
[67] P. Hohl, et. al, "Back to the future: origins and directions of the "Agile Manifesto"–views of the originators", Journal of Software Engineering Research and Development, Vol.6, No.1, pp.15, 2018.
[68] I. Jacobson, R. Stimson, and S. Hastie, "Escaping Method Prison", 2017. Available at: http://semat. org/news/-/asset_publisher/eaHEtyeuE9wP/content/escaping-method-prison.
[69] S. Adolph, "What lessons can the agile community learn from a maverick fighter pilot?", AGILE 2006 (AGILE'06), IEEE, 2006.
[70] E. Markopoulos, and J. C. Panayiotopoulos, "A project management methodology selection approach based on practical project and organizational constraints", WSEAS Transactions on Computers, Vol.4, No.8, pp.934-942, 2005.
[71] M. C. Annosi, N. Foss, and A. Martini, "When Agile Harms Learning and Innovation:(and What Can Be Done About It)", California Management Review, Vol. 63, No. 1, pp.61-80, 2020.
[72] B. Henderson-Sellers and M. K. Serour, "Creating a dual-agility method: the value of method engineering", Journal of Database Management, Vol. 16, No. 4, pp. 1–23, 2005.

[73] B. Boehm, and R. Turner, *Balancing Agility and Discipline: A Guide for the Perplexed*. Boston: Pearson Education Inc., 2004.
[74] K. Petersen, "Is lean agile and agile lean?: a comparison between two software development paradigms", Modern software engineering concepts and practices: Advanced approaches, IGI Global, pp. 19-46, 2011.
[75] J. P. Womack and D. T. Jones, *Lean thinking: Banish waste and create wealth in your corporation*. London: Free Press Business, 2003.
[76] J. Naylor, M. Naim, and D. Berry, "Leagility: Integrating the Lean and Agile Manufacturing Paradigm in the Total Supply Chain", Engineering Costs and Production Economics, Vol. 62, p.107 118, 1999.
[77] T. Ohno, *The Toyota Production System: Beyond Large Scale Production. Portland*. OR: Productivity Press, 1988.
[78] D. Towill, and M. Christopher, "The Supply Chain Strategy Conundrum: To Be Lean or Agile or To Be Lean and Agile", International Journal of Logistics: Research and Applications, Vol.5, No.3, 2002.
[79] R. Dove, "The Meaning of Life and The Meaning of Agility, Paradigm Shift International", 1997. Available at: http://www.parshift.com/library.htm/
[80] H. Volberda, *Building the Flexible Firm: How to Remain Competitive*, New York: Oxford University Press, 1998.
[81] M. Aoyama, "Agile software process and its experience", 20th international conference on Software engineering, IEEE, pp. 3-12, 1998.
[82] T. Schweigert, R. Nevalainen, D. Vohwinkel, M. Korsaa, and M. Biro, "Agile maturity model: oxymoron or the next level of understanding", International Conference on Software Process Improvement and Capability Determination, Springer, Berlin, Heidelberg, pp.289-294, 2012.
[83] I.P. Barclay, and Z. Dann, "Improving competitive responsiveness via the virtual environment", Engineering and Technology Management. Pioneering New Technologies: Management Issues and Challenges in the Third Millennium, IEMC, Vancouver, 1996.
[84] J. Iivari, and N. Iivari, "The relationship between organizational culture and the deployment of agile methods", Information and software technology, Vol. 53, No.5, pp.509-520, 2011.
[85] M. Salo, E. Markopoulos, H. Vanharanta, and J. I. Kantola, "Degree of agility with an ontology based application", Advances in Human Factors, Business Management, Training and Education, Springer, Cham, pp.1007-1018, 2017.
[86] P. Abrahamsson, M. A. Babar, and P. Kruchten, "Agility and architecture: Can they coexist?, IEEE Software, Vol. 27, No. 2, pp.16-22, 2010.
[87] M. van Oosterhout, E. Waarts, E. van Heck, and J. van Hillegersberg, "Business agility: need, readiness and alignment with IT-strategies", Agile Information Systems: Conceptualization, Construction and Management, pp.52-69, 2006.
[88] D. X. Houston, "Agility beyond software development", 2014 International Conference on Software and System Process, pp. 65-69, 2014.
[89] L. Gren, R. Torkar, and R. Feldt, "Group Maturity and Agility, Are They Connected?-A Survey Study", 41st Euromicro Conference on Software Engineering and Advanced Applications, IEEE, pp.1-8, 2015.
[90] M. Müller-Amthor, G. Hagel, M. Gensheimer, and F. Huber, "Scrum Higher Education–The Scrum Master Supports as Solution-focused Coach", IEEE Global Engineering Education Conference (EDUCON), IEEE, pp. 948-952, 2020.
[91] A. A. Albarqi, and R. Qureshi, "The proposed L-Scrumban methodology to improve the efficiency of agile software development", International Journal of Information Engineering and Electronic Business, Vol. 11, No. 3, 2018.
[92] M. R. J. Qureshi, and A. Albarqi, "Proposal of new PRORISK model for GSD projects", International Journal of Information Technology and Computer Science, Vol. 6, No. 6, pp.38-44, 2015.
[93] A. S. AL_Zaidi, M. R. J. Qureshi, and M. R. Jameel Qureshi, "Scrum practices and global software development", International Journal of Information Engineering and Electronic Business, Vol. 6, No. 5, pp.22-28, 2014.

Authors' Profiles

Necmettin Ozkan has first-hand professional experience in IT quality, process and performance management and Agile Software Development. Among the frameworks, he closely works with ITIL, COBIT, Scrum and Kanban. He is passionate about contributing to the body of knowledge by sharing with public speaking, academic publications and as a reviewer for international journals and conferences. He is working toward his Ph.D. degree at Gebze Technical University and as the IT Quality Team Leader at Kuveyt Turk Participation Bank. His research interests include agile software development and agility. Contact him at necmettin.ozkan@kuveytturk.com.tr.

Mehmet Sahin Gok is an associate professor at Gebze Technical University, Turkey. He obtained his Ph.D. in operations management from Gebze Institute of Technology in 2012. He was a visiting scholar at the Carlson School of Management, University of Minnesota, during 2009–2010. His research interests focus on benchmarking analysis, efficiency analysis, service management, project management, and innovation management. His research appeared in SSCI index journals such as Journal of Intellectual Capital, Sustainability, International Journal of Hospitality Management, Service Management, Kybernetes, Health Policy, International Journal of Market Research, Materials Evaluation, and European Journal of Health Economics. Contact him at sahingok@gtu.edu.tr.

How to cite this paper: Necmettin Ozkan, Mehmet Sahin Gok, " Definition Synthesis of Agility in Software Development: Comprehensive Review of Theory to Practice", International Journal of Modern Education and Computer Science(IJMECS), Vol.14, No.3, pp. 26-44, 2022.DOI: 10.5815/ijmecs.2022.03.02