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# Knowledge Management in Software Testing

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**Abstract**

Software testing aids in the assessment and improvement of software quality. Software testers employ a variety of techniques to uncover more defects with the least amount of labour even though the testing necessitates a lot of knowledge. Since adherence to Knowledge Management concepts can assist software testing professionals in their advancement of knowledge reuse, sharing, and testing process, this study is therefore aimed at identifying the Knowledge Management practices in software development organizations as well as to ascertain whether Knowledge Management has benefitted the organizations. To realise this goal, a survey was conducted among fifteen software developers from fifteen software development organizations. Descriptive and inferential statistics were employed using simple descriptive statistics and crosstabs. This study found out that the software developers are familiar with the Knowledge Management concepts and six Knowledge Management. These are knowledge acquisition, creation, sharing, storage, organization and application. The study also shows that Knowledge Management has made organizations developing software improve in their software testing processes by saving time and avoiding the need to reinvent the wheel as well as increased their level of productivity.

***Keywords:*** Software testing, Knowledge Management, Software developers, Knowledge Management Practices

## 1. Introduction

Knowledge management refers to a strategy of streamlining the procedure of distributing, sharing, capturing, creating, and understanding knowledge. It has also been identified as a means of gaining an advantage in the marketplace for organizations that are successful, efficient and prolific [6].

The process of distributing, capturing, and utilizing knowledge efficiently is known as knowledge management [11]. It is a means for deploying, managing knowledge and information of the organization [7].

According to Nonaka and Takeuchi [14], one of an organization's most significant assets is its knowledge. The two basic types of knowledge are explicit and tacit knowledge. To distinguish between unarticulated and articulated knowledge, the tacit-explicit distinction is employed.

As stated by Mohajan [12], knowledge is a combination of experience, relevant processed data and competent insight that serves as a framework for evaluating and incorporating new experiences and processed data. Knowledge has become an essential component of any organization as a result of recent advances in science and technology. In organizations, knowledge is regarded as a repository of intelligence for the advancement of the organization. Knowledge is a real belief that is supported by evidence [4].

Undocumented, subjective and experience-based knowledge is referred to as tacit knowledge and usually exists solely in people's heads. Personal experience is required for this form of knowledge, which includes intangible aspects such as beliefs, viewpoints, intuition

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and values [14]. Unarticulated knowledge associated with senses, movement abilities, physical experiences, intuition, or unwritten rules of thumb is known as tacit knowledge. Regardless of what we do, we will never be able to adequately articulate this form of knowledge [13]. Software testing includes test execution experiences and brainstorming with software testers.

In contrast, explicit knowledge denotes objective and reasonable knowledge that can be recorded and made available to a large number of people [14]. In software testing, it includes documents such as test manuals, the procedure of testing and also test artifacts. Explicit knowledge is easily expressed and documented in drawings and writing, and it is permissible to use and distribute.

During the Software Development Life Cycle (SDLC), software testing is an important process. Testing software components for integrity, stability, efficiency, portability, maintainability, compatibility and usability has become critical. One of the major goals of software testing is to increase the quality of the software. One of the most difficulties confronting software organizations is the production of trustworthy software. Organizations developing software are striving to enhance the standard of the product.

However, technological advancements and the development of critical systems have made testing a difficult procedure, and a substantial amount of data is produced. With this in mind, testing knowledge should be managed in an effective manner that will be useful to the organization as a whole.

In many software development organizations, there is lack of transparency of organizational knowledge. Experiences and knowledge gained from previous projects are limited to each individual and are not being shared within the organization or team members [1]. Valuable knowledge about software testing is lost and not used, the moment the people who have them are no longer available. Whereas, the general purpose of Knowledge Management is to make knowledge usable for more than one individual and for an organization as a whole to share it. Since software testing is an activity that requires a lot of knowledge, many organizations have expressed their interest in incorporating Knowledge Management into the software testing processes and this has helped software testing experts to advance the knowledge creation, storage, reuse, sharing, application and procedure of testing.

Knowledge, skills and experience in software testing are all essential. Software testing is a highly specialized task that necessitates a substantial amount of knowledge, the use of Knowledge Management methods and principles improves the utility of software testing. To reap the benefits of Knowledge Management in terms of price and value, it must be integrated into the core process of software testing [18].

Hence, this study finds out more about the practice of Knowledge Management in software development organizations and assessing the organizational benefits of Knowledge Management.

## 2. Related Works

Souza *et al.* [18] considered testing of software as a knowledge-intensive activity, and principles and techniques of Knowledge Management (KM) should be implemented to handle knowledge about software testing. The study provides a survey of currently available research on Knowledge Management efforts in software testing to assess current and future research. Goals, knowledge types, technology and research type were all investigated. Seven electronic databases were searched for the mapping project. They looked at papers that had been published up until December of 2013. The initial set of results included 562 studies.

From this set, 13 studies were chosen. They found the papers of the scholars and study groups who completed these investigations using snowballing and a direct search for these 13. Based on the mapping study, they discovered 15 studies covering KM efforts in software testing, which they analyzed to gather pertinent data on a set of research questions. Even though only a few research studies covered KM efforts in software testing, the

mapping demonstrates that in recent years, there has been a surge of interest in the topic. The perspective that has garnered the most attention is the reusing of test cases.

From the viewpoint of knowledge management, the majority of the studies looked at elements about the provision of automated assistance for managing testing knowledge via the use of a KM system. In addition, as a key conclusion, the findings suggest that knowledge management (KM) is a key strategy for improving test effectiveness as well as the selection and deployment of appropriate techniques, procedures and test cases. The most frequently mentioned issue with the use of KM in software testing, on the other hand, is the inadequacy of existing KM systems.

In 2014, Rory and Shuib [16] noted that systems and software engineering is different from other types of engineering in that it operates with an intangible product in which construction progress is not explicitly visible and team members frequently rely on the others' documentation to track and review progress. Moreover, in contrast to traditional engineering fields, there is no single standard procedure.

The literature on knowledge management in software engineering is increasingly important, as software development is primarily a human knowledge demanding activity and many consider it a critical aspect. The study looked at the role of software development knowledge management in the software development process, in particular, how software development knowledge is managed in software development to promote software process improvement and the role of knowledge management in this. The authors presented the findings of an investigation of knowledge management process practices in very small software companies and discussed them with the major issues that have been identified: Communication, Learning and Sharing; Documentation and Knowledge management process and commitment. The study's findings shed light on knowledge management methods as they apply to software development process practices in very small organizations, as well as the critical variables that must be taken into account to retain quality software and knowledge.

Liu Xuemei *et al.*, [10] emphasized the importance of efficient knowledge management of the testing process in software testing organizations for improving software testing quality. Different aspects of knowledge management are present in software testing. As part of the research, a knowledge management model for the software testing process was developed, which is based on developing the site of knowledge sharing. It highlights the importance of working closely with knowledge services and software testing and how it will advance research in knowledge management technology. Numerous important technologies, such as knowledge representation and knowledge mapping, were discussed at the same time. Finally, in the QESuite2.0 project, an application instance based on this model is provided.

James and Aybuke [9] noted that Knowledge and experience management are critical components of systematic software development and process improvement, quality remains a source of concern in the realm of Software Engineering (SE). Knowledge Management (KM) allows organizations to grasp the issues and complexities that come with software development. The research work included two case studies on KM in SE in two different IT organizations. A qualitative questionnaire was used to conduct structured interviews. The findings were used to define existing KM practices in SE, investigate the nature of these organizations' KM activities, and explain the role of leadership, technology, culture, and measurement as KM process facilitators in SE.

Hillary [8] suggested that as important as the concept of knowledge management is, it should be treated as a major component of the organizational learning process rather than as a separate management concept. Indeed, knowledge management is and should be an extension of organizational learning because there will be no knowledge to manage if there is no learning. This paper also revealed that the main factors preventing organizational members from sharing knowledge are lack of

interpersonal relationships, lack of organizational trust, skills and lack of time.

In Claudia *et. al*., [15] software testing has been described as a knowledge-intensive process, and as such, it can benefit from the use of previous project experience. Knowledge Management (KM) principles can be applied in this context to promote knowledge capture and sharing, as well as the emergence of new knowledge. Despite this, only a few studies have been conducted to present practitioners' perspectives on KM initiatives in software testing. The study's main goal is to identify software testing professionals' perceptions of the use of KM initiatives in software engineering companies, such as KM adoption, potential benefits, or hindrances. A survey was carried out in software development firms. Furthermore, the survey results were compared to those of a previous survey conducted in the same context but with different objectives and target audiences. The study involved 39 software companies. Companies have paid more attention to the testing planning activity and the test case reuse. Strategic planning and reusing existing test cases have the potential to significantly lower software development costs and time. Using KM in software companies can provide several advantages in terms of quality of results, cost reduction, time and effort savings. However, it remains a challenge that must be met and overcome.

Ramadhan and Setiyani [15] stated that the development process of software affects its quality. In general, the software development process includes several stages such as project management, system requirements analysis, architecture and design, implementation, and testing. It is impossible to separate each of these stages from the process of capturing, storing, transferring and sharing knowledge between the developer and the stakeholders. The purpose of this systematic review was to examine the knowledge management process in the software development process. The authors followed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines in their systematic review. They examined twenty-two works of literature from various publishers and examined the knowledge management process in software development. According to the findings, the knowledge management process plays a critical role in improving the quality of software developed. According to the findings of this systematic review, knowledge management is one of the factors determining software quality.

Anupan *et al*. [2] aimed to use a knowledge engineering approach to design a framework for a knowledge management system in a cloud computing environment. There were two steps to the research. The first one utilizes a knowledge engineering approach to analyze and synthesize relevant literature on knowledge management systems in a cloud computing environment and the second one uses a knowledge engineering approach to design a framework for a knowledge management system in a cloud computing environment. Content analysis was used to analyze the data. The following are the four components of a knowledge management system: 1) knowledge retrieval 2) knowledge storage 3) knowledge sharing and 4) knowledge publishing. The knowledge engineering approach is made up of three parts, which are as follows: 1) knowledge acquisition 2) knowledge storage and 3) knowledge utilization.

## 3. Methodology

In this study, the practices of Knowledge Management in software development organizations were found out empirically and the benefits of Knowledge Management were determined. According to the findings of this study, organizations developing software are organizations whose main line of business is software development. Software vendors are exempted because they do not produce software but rather sell it. Fifteen software development organizations were discovered in Ibadan, Oyo State of Nigeria. It is appropriate to use software development organizations in Ibadan due to proximity.

A survey was carried out using a self-administered questionnaire designed to collect the data. The questionnaire was structured into two parts. Section 1 focused on demographic details of respondents and section 2 focused on knowledge management practices. Experts

verified and validated the face-validity and Content-validity of the questionnaire. The various recommendations received were used to improve the questionnaire while the test-retest approach was used to assess its consistency and reliability.

Fifteen software development project managers participated and completed the questionnaires. The sampling technique used is simple random sampling. This is a method for picking a representative sample from a given population of data for use in a survey.

The responses from the questionnaires were analyzed using simple descriptive statistics and crosstabs. The following research questions were formulated:

Q1: Do you encounter Knowledge gaps?
Q2: Do you transfer knowledge in your organization?
Q3: Do you store Knowledge in your organization?
Q4: Do you organize knowledge in your organization?
Q5: Do you apply the stored knowledge in your organization?
Q6: What benefits do your organization get from Knowledge management?

## 4. Results and Discussion

### 4.1 Results

This section contains the demographic data of the responses of the fifteen software project managers received and summarizes the key findings for each research question. The demographic information of survey respondents is summarized in Table 1.

In Table 1, out of 15 respondents, 11 (73.3%) were males and 4 (26.7%) were Females. 26.7% of the respondents were 21-25 years of age, 53.3 % of the respondents were 26-30 years of age and 20% of the respondents were 31yrs and above. 26.7% of the respondents were graduates and 73.3% were Postgraduates.

The role that respondents currently assume is also shown in Table 1. All the respondents were software development managers. 26.7% of Respondents have held their current roles for more than five years. 53.3% of respondents have been in their current roles for 2 to 5 years and 20% of respondents have held their current roles for less than two years.

**Knowledge management practices in software development organizations**

The findings show five Knowledge management practices in the fifteen organizations developing software: knowledge acquisition, sharing, storage, organization, and application. They are discussed in detail next.

**Table 1: Respondents' Demographic Characteristics**

| | | **Frequency** | **Percent** |
|---|---|---|---|
| **Sex** | Male | 11 | 73.3 |
| | Female | 4 | 26.7 |
| | **Total** | **15** | **100.0** |
| **Age** | 21-25 | 4 | 26.7 |
| | 26-30 | 8 | 53.3 |
| | 31 above | 3 | 20.0 |
| | **Total** | **15** | **100.0** |
| **Level of Education** | Graduate | 4 | 26.7 |
| | Postgraduate | 11 | 73.3 |
| | **Total** | **15** | **100.0** |
| **Current Working role** | S/W Dev. Manager | 15 | 100.0 |
| | **Total** | **15** | **100.0** |
| **Years worked in current role** | Less than 2 years | 3 | 20.0 |
| | 2 to 5 years | 8 | 53.3 |
| | More than 5 years | 4 | 26.7 |
| | **Total** | **15** | **100.0** |

**Research Question 1: Do you encounter Knowledge gaps?**

**Table 2: Do you encounter Knowledge gaps**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 15 | 100.0 | 100.0 | 100.0 |

**Table 3: Internal sources you employ to fill knowledge gaps**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Employees | 7 | 46.7 | 46.7 | 46.7 |
| | Organizational Documents | 2 | 13.3 | 13.3 | 60.0 |
| | Code samples | 4 | 26.7 | 26.7 | 86.7 |
| | Emails | 2 | 13.3 | 13.3 | 100.0 |
| | Total | 15 | 100.0 | 100.0 | |

**Table 4: External sources you use to fill the knowledge gaps**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Internet | 11 | 73.3 | 73.3 | 73.3 |
| | Customer/Clients | 2 | 13.3 | 13.3 | 86.7 |
| | Industry Networks | 2 | 13.3 | 13.3 | 100.0 |
| | Total | 15 | 100.0 | 100.0 | |

**Research Question 2: Do you transfer knowledge in your organization?**

**Table 5: Do you transfer knowledge in your organization**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 15 | 100.0 | 100.0 | 100.0 |

**Table 6: In your Organization knowledge is transferred by**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Meetings | 2 | 13.3 | 13.3 | 13.3 |
| | Internet | 6 | 40.0 | 40.0 | 53.3 |
| | Brainstorming sessions | 7 | 46.7 | 46.7 | 100.0 |
| | Total | 15 | 100.0 | 100.0 | |

**Research Question 3: Do you store Knowledge in your organization?**

**Table 7: Do you store knowledge in your organization**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 15 | 100.0 | 100.0 | 100.0 |

**Table 8: Method/Technology used to store knowledge in your organization**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Servers | 9 | 60.0 | 60.0 | 60.0 |
| | Email System | 2 | 13.3 | 13.3 | 73.3 |
| | Cloud | 4 | 26.7 | 26.7 | 100.0 |
| | Total | 15 | 100.0 | 100.0 | |

**Research Question 4: Do you organize knowledge in your organization?**

**Table 9: Do you organize knowledge in your organization**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 15 | 100.0 | 100.0 | 100.0 |

**Table 10: Technique/tool used to organize knowledge in your organization**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Folders | 15 | 100.0 | 100.0 | 100.0 |

**Research Question 5: Do you apply the stored knowledge in your organization?**

**Table 11: Do you apply the stored knowledge**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Yes | 13 | 86.7 | 86.7 | 86.7 |
| | No | 2 | 13.3 | 13.3 | 100.0 |
| | Total | 15 | 100.0 | 100.0 | |

**Table 12: How often do you apply the knowledge?**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Daily | 9 | 60.0 | 60.0 | 60.0 |
| | Occasionally | 4 | 26.7 | 26.7 | 86.7 |
| | Never | 2 | 13.3 | 13.3 | 100.0 |
| | Total | 15 | 100.0 | 100.0 | |

**Research Question 6: What benefits do your organization get from Knowledge management?**

Table 13 shows a summary of the Cross Tabulation Analysis carried out on the benefits gained from knowledge management

**Table 13: Cross tabulation analysis**

| | | | | | | Total |
|---|---|---|---|---|---|---|
| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree | |
| Knowledge Management has improved your processes | 0 | 0 | 4 | 6 | 5 | 15 |
| Knowledge Management has made the organization more accurate | 0 | 2 | 2 | 11 | 0 | 15 |
| Knowledge Management has made the organization effective | 0 | 0 | 0 | 15 | 0 | 15 |
| Knowledge Management has made the organization efficient | 0 | 0 | 0 | 13 | 2 | 15 |
| Knowledge Management has made the organization save time | 0 | 0 | 0 | 15 | 0 | 15 |
| Knowledge Management has prevented reinvention of the wheel | 0 | 0 | 6 | 9 | 0 | 15 |

## 4.2 Discussion

This section discusses the results presented in the previous section.

**From the results presented for Research Question 1:**
100% of the respondents said they encountered knowledge gaps. 46.7% acquired knowledge internally from employees, 13.3% acquired knowledge internally from organizational documents, 26.7% acquired knowledge internally from code samples, and 13.3% acquired knowledge internally from emails. 73.3% acquired knowledge externally from the internet, 13.3% acquired knowledge externally from Customers/Clients, and 13.3% acquired knowledge externally from Industry networks. The results reveal that all the fifteen organizations developing software do encounter knowledge gaps and rely on a variety of internal and external sources to fill those gaps. Employees, organizational documents, code samples, and emails are used to acquire knowledge internally. Customers/clients, the Internet and industry networks are examples of external knowledge sources.

**From the results presented for Research Question 2:**
100% of the respondents said they do transfer knowledge in their organization. 13.3% transferred knowledge by meetings, 40% transferred knowledge by the Internet and 46.7% transferred knowledge by brainstorming sessions. The results indicate that knowledge is transferred in the organizations developing software by holding meetings, use of the internet, and brainstorming sessions.

**From the results presented for Research Question 3:**
100% of the respondents said they do store knowledge in their organization. 60% use servers to store their knowledge, 13.3% use the email system to store their knowledge and 26.7% use the cloud to store their knowledge. According to the findings, organizations developing software use a variety of systems to store their knowledge.

**From the results presented for Research Question 4:**
100% of the respondents said they do organize knowledge in their organization. 100% use folders to organize their knowledge. The results reveal that organizations developing software organize their knowledge resources using basic organization techniques such as folders.

**From the results presented for Research Question 5:**
86.7% of the respondents said they do apply the stored knowledge in their organization and 13.3% of the respondents said they do not apply the stored knowledge in their organization. 60% apply the stored knowledge daily, 26.7% apply the stored knowledge occasionally and 13.3% never apply the stored knowledge. The results reveal that organizations developing software apply the stored knowledge at their disposal in their development tasks.

**From the results presented for Research Question 6:**
26.7% of the respondents are neutral, 40% of the respondents agreed and 33.3% strongly agreed that knowledge management has improved their processes. 13.3% of the respondents disagreed, 13.3% of the respondents are neutral and 73.3% of the respondents agreed that knowledge management has made the organization more accurate.

100% of the respondents agreed that knowledge management has made the organization effective. 86.7% of the respondents agreed and 13.3% of the respondents strongly agreed that knowledge management has made the organization efficient. 100% of the respondents agreed that knowledge management has made the organization save time. 40% of the respondents are neutral and 60% of the respondents agreed that knowledge management has prevented reinvention of the wheel. The results reveal that knowledge management has made organizations developing software more precise, effective, efficient, and productive by saving time and avoiding the need to reinvent the wheel.

## 5. Conclusion

The research found six knowledge management practices in organizations developing software: Knowledge acquisition, creation, sharing, storage, organization and application. Managers' responses indicate that knowledge management practices have improved processes in software development organizations in some way.

According to the study, software development organizations have adopted Knowledge Management practices, which have made them more effective, efficient, and productive. This survey could be extended to more organizations developing software in other parts of Nigeria.

The study of knowledge management in software testing is critical for improving the quality of software products and its economic benefits. It also promotes the nuclear competitive power of software enterprises.

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