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A Structured Requirements Analysis Approach of Multiple Intelligence Test Application Using Activity Theory Framework

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Abstract: The use of mobile applications has increased tremendously. As a result, there is a flood of smartphone applications on the market which makes the quality of the applications uncertain. Carrying out the right requirements analysis process is necessary to ensure quality of the products that meet the user needs. This paper proposes a structured requirements analysis approach using Activity Theory model to analyze the requirements of mobile application by using multiple intelligence test application as a case study. The result of this study revealed that activity theory can be used as an alternative approach of requirements engineering activity, particularly for the requirements analysis.

Keywords: Activity theory, Gardner's theory, Mobile Application, Multiple Intelligence, Requirements Analysis, Requirements Engineering

1. Introduction

Requirements analysis involved analyzing the user needs by focusing on the system's functions and environment and this activity often takes place after the elicitation (Gunawardhana, 2019). Requirements analysis concentrate on how user understand and interact with their environment process. Requirements analysis is a vital requirements engineering activity as it allows the development team to catch the problems early which may avoid failure in a software project (Ahmad, 2016) and to produce usable products (Nik Ahmad & Hussaini, 2021). Various traditional approaches were used for requirements analysis such as role activity diagrams (Abushark et al., 2017) and business process model notation (Mutarraf et al., 2018). However, new requirements engineering method that supports distinctive features of the application is needed (Ahmad & Kasirun, 2011). Therefore, this study explores the use of activity theory in analyzing the requirements using alternative approach; an activity theory for a multiple intelligent test application that applied Gadner's Theory of multiple intelligence which was developed for counselling unit. The application offers a mobile-based test, which focus on assessing the students' intelligence level, which then can be used by the counsellor to consult the students on their future career path. The consultation will be based on results attained after attempting the intelligent test and report, because different people have different intelligence which lead to different ways of learning (Serpes, 2019). Gardner's multiple intelligence is divided into nine categories which sometime be addressed as the nine domains of intelligence (Ahmad & Dzulkarnain, 2020). With the purpose to better understand the interaction between the students and counsellor, who are the primary users of this application, activity theory was used to explain how they relate to each other with the use of tools.

2. Related Works

2.1 Activity Theory

Activity theory was first recommended by Vygotsky in the year 1978 which described how subjects interact with a given object to reach specific goal (Vygotsky, 1978). Vygotsky theory was solely based on the individual rather than the user community and he believed that human activity is facilitated which caused changes in the outcome. After the theory was introduced by Vygotsky as a psychological theory, it was then redesigned by (Leontev, 1978) by adding different structural activities to it. Later, this idea was challenged by Engeström who stated that tools are just merely mechanisms which affect the human activity function (Engeström, 2014), which, if driven from his idea mediation is the result of the entire components of the system and not only bounded by a single individual (Ashritha et al., 2017). Engeström (2014) was then added few of his concepts and came up with the activity model that we know today.

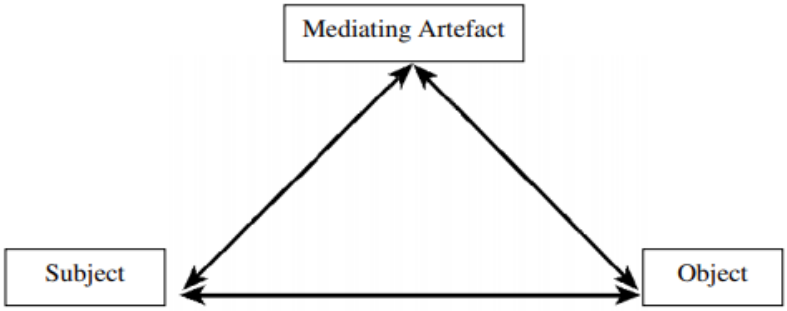

Fig. 1 A derivation of Vygotsky's original model of a mediated act (Engeström, 2014)

Engeström's modification of Vygostky's original theory involved two additional elements which are rules and division of labor. Rules was included as a condition to determine how and why individuals may react to situation while division of labour involves actions and operations delegation among community. Basic Activity Theory with the additional from Engestrom's concepts are illustrated in Figure 2.

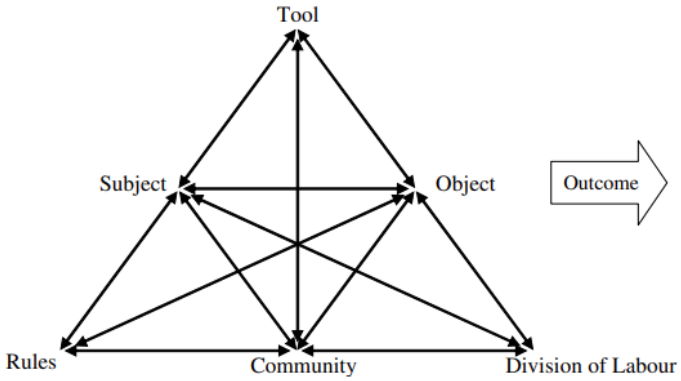

Fig. 1 Engeström's expanded activity theory model (Engeström, 2014)

Activity Theory argues that activities can only be interpreted through an analysis of their historical-cultural extension within a given context, in order to represent the human interaction with their social environment (Ekundayo & Clear, 2018). However, it comes from the analysis of individual's activity and objective, and at the same time analyze their tools and its mediation through rules, and community, where the tool is called as mediating artefact

(Rismani et al., 2016; Riechert et al., 2016), and this is how activity theory works. As the name suggests, the core element of activity theory is activity, where this activity has a layered hierarchical structure comprised by responses or sequence of actions, and these actions are comprised of operations (Gonçalves, 2017).

2.2 Application of Activity Theory

Activity Theory has been applied in various contexts (Méndez & Lacasa, 2015), including educational design, human-computer interaction and information technology (Rismani et al., 2016). A study has revealed that activity theory has the ability to understand the requirements by involving the system participants during qualitative data analysis through a school's integration project (Chu et al., 2016). Activity theory framework was also used to analyze the user interactions in healthcare system Riechert et al., 2016), and as a requirement analysis tool for Muslim-based application (NikAhmad, 2013). Activity theory was also used in combination with another requirements elicitation techniques such as interview and observation, in exploring the user activities (Ni et al., 2020). Another study has applied activity theory for learning robotics model (Maouch et al., 2019), to examine the role of devices within a socioeconomic system (Rismani et al., 2016), to analyze the relevant information for m-learning application (Fazeena et al., 2015), as a creative problem process to design collaborative learning activities (Prapinpongsakorn et al., 2017), and as an analysis tool for activity classification model for Interactive Systems (Villegas et al., 2016). Activity theory was also found in game development and analysis, where it was used to determine how the different elements of the games are interconnected with each other (Carvallo et al., 2015), and to describes the features educational games through mediated activities (polin, 2018) besides being used as a foundation to prepare changes caused by the initiation of commercial video games for special needs students at a middle school (Chu et al., 2016).

2.3 Multiple Intelligence Using Gardner's Theory

In early 1980s, Gardner has suggested the theory of multiple intelligences as an option to traditional classroom designs which cater variety ways people learn and convey information (Şener & Çokçalışkan, 2018). Since then, the theory of multiple intelligences has been widely adapted and referred by scholars who dealt with human cognition study. Intelligence is a very broad term which can take on different meanings and has been defined in several different ways (Sreenidhi, 2017). As stated by Gardner, human intelligence cannot be measured by one single competency. The human intelligence is categorized into nine which are logical-mathematical (number smart), verbal-linguistic (word smart), bodily-kinesthetic (body smart), musical-rhythmic (music smart), interpersonal (people smart), visual-spatial (picture smart), intrapersonal (self-smart), the naturalist (nature smart), and existential (Gardner, 2000). The significant were that different people had different ways of learning, and therefore intelligent should be measured in different way and not to depend on traditional academic achievement alone (Serpes, 2019).

3. The Requirements Analysis Using Activity Theory Framework

This requirements analysis study is a post-activity of requirements elicitation, which means prior data (requirements) was collected using interview method with counsellor and secondary school students at Puteri Secondary School during elicitation. The requirements

were then analyzed using activity theory with three requirements analysis steps as shown in figure 3.

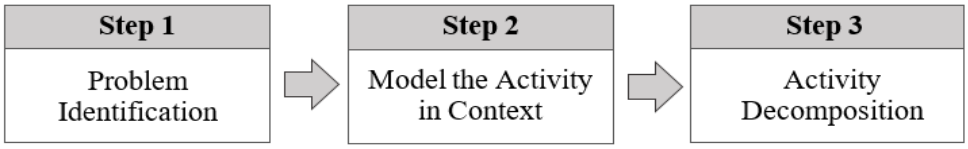

Fig. 3 The Requirements analysis approach

Step 1:
The first step starts with identifying potential activities of the application based on elicitation report (since this is a post-elicitation activity). Activities were then prioritized and classified according to user type. This step has affirmed two users for the application which are counsellors and students and the main activities are attempting multiple intelligence test through mobile application, and accessing test report for counselling purpose.

Step 2:
Step 2 involved analyzing the six activity theory elements for the application which are subject, object, tools, rules, community, and division of labor. All the 6 elements are identified in context. The following figure 4 shows the activity diagram for the context of students attempting the online test which resulted in identified intelligence categories by the application. The test questions were formed according to Gardner's theory of intelligence, comprised of 40 questions covered the 9 intelligence categories. The student was identified as subject in this context.

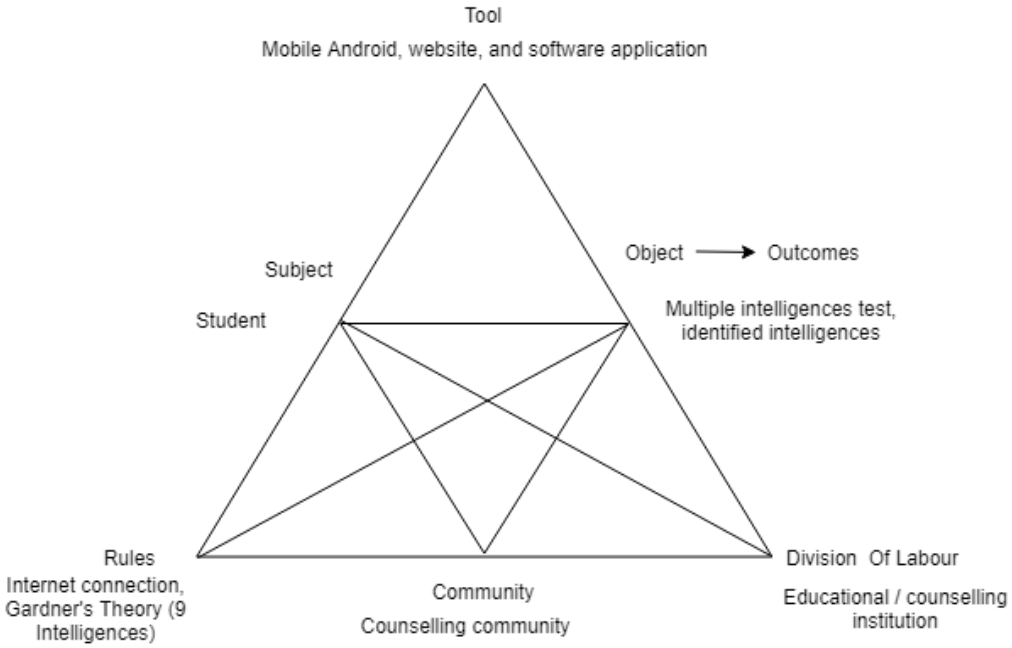

Fig. 4 Analysis of attempt test requirements in the context of student

Figure 5 illustrates the activity diagram for the context of counsellor performing students' registration to the counselling system and access the identified intelligence report while Figure 6 focused on multiple intelligence report accessed by the counsellor in both textual and graphical format. The report displayed the score for each category. The counsellor was identified as subject in these context.

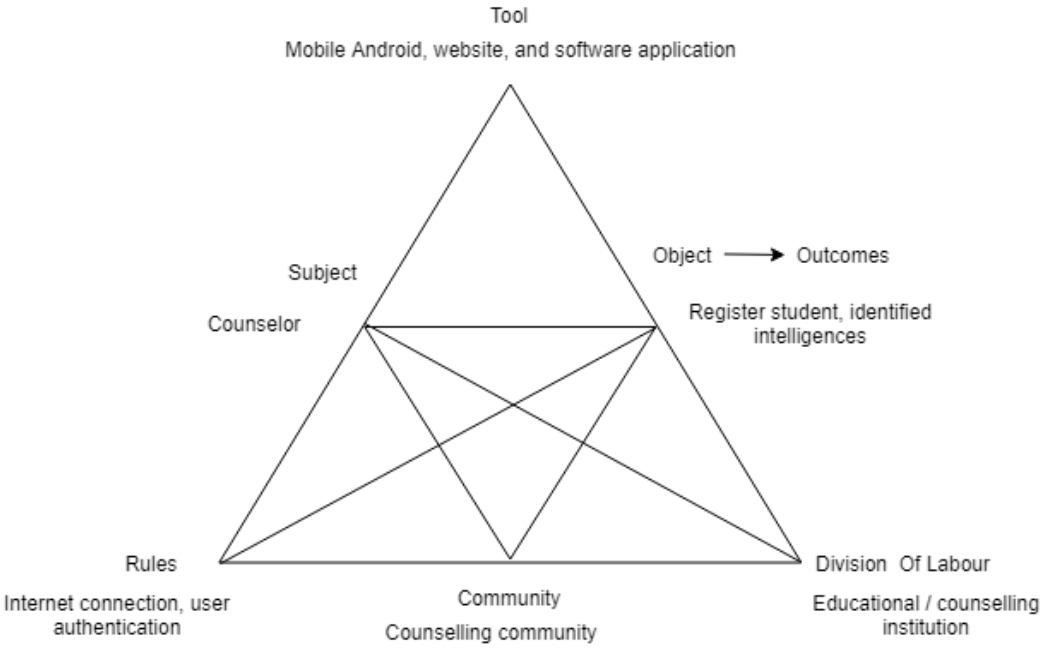

Fig. 5 Analysis of the counsellor activity context

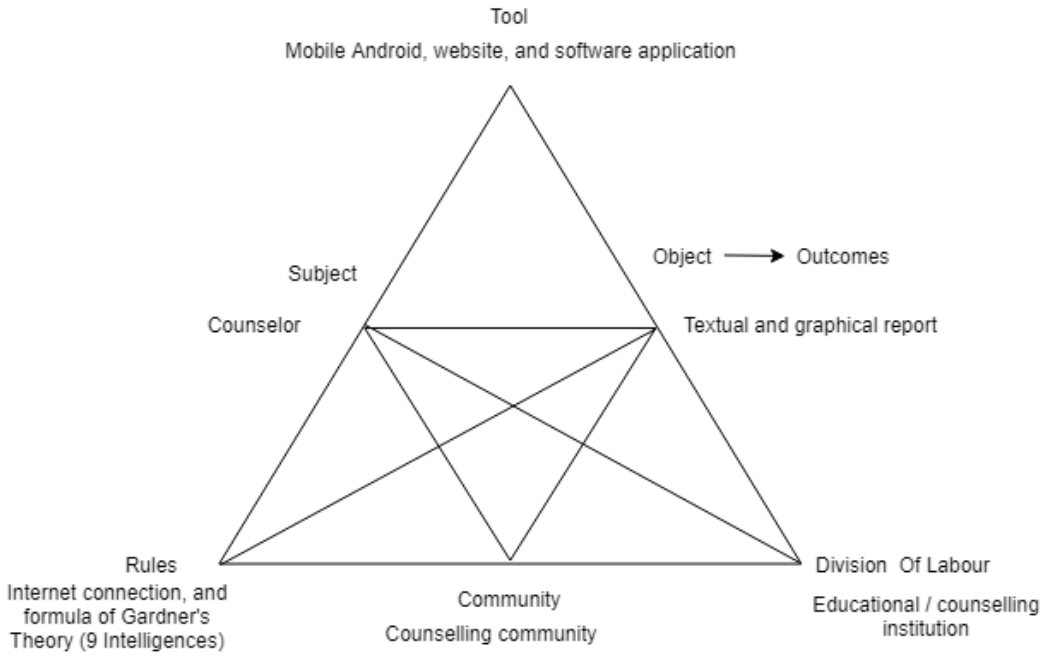

Fig. 6 Analyze the requirement of report activity

Step 3:

This step involved activity decomposition into actions and operations (Nguyen & Poo, 2019), where activity has a layered hierarchical structure comprised of actions, and these actions are composed of operations (Goncalves et al., 2014) to further elaborate the action accordingly. The activity decomposition is presented in Table 1.

Table 1. Decomposition of activity into actions and operations

Activity	Actions	Operations
Attempt Test (Student)	Access test	Access through mobile application
	Fill up details	Fill up student's details in form
	Attempt test	Choose by category (Gardner's 9 multiple intelligence category)
		Answer all questions by categories
	Submit test	Process result
	Display	Display the result by Gardner's category
Register Student (Counsellor)	Log in	Input credentials
	Register	Register student for counselling session
Access Result Report (Counsellor)	Access Result	Access result module
		Search student's details
	Display	View student's intelligence test results
		Choose report type, text or graphical
		Log counselling session

4. Discussion

The core activities for multiple intelligence test application which will be used by counsellor and secondary school students were illustrated in Figure 1 – 3, with detail analysis presented in Table 1. From the steps above, the study illustrated 3 Activity Theory models that represent student and counselor activities. For the student context, the outcome is identified intelligences which are conducted from the Gardner's Theory. Students may attempt the intelligences test through website or mobile application with a good internet connection as condition. Figure 5 and 6 illustrated the counsellor activity context, which involved students' registration for the counselling session and accessing the test results in textual and graphical format. The results will be used as reference for the counselling purpose.

Activity theory is suitable alternative approach for requirements analysis, which should be conducted after the requirements elicitation took place (post elicitation technique) as requirements analysis activity requires data to be collected in prior. The structured specification outlined from these study can be used for further software development activity such as design and implementation with the application of six activity theory elements in context which are subject, object, tools, rules, community, and division of labor. With the use of activity decomposition approach, the information is more organized and easier to comprehend, while also contributing to the overall ease of the requirements management process. As a result, this approach will reduce the analysis time.

5. Conclusion

This study has used the activity theory approach to analyze the requirements of a multiple intelligence test application that was designed to be used by counsellor to consult the students on their career path according to the students' strength (intelligence). The approach has taken into account the structured requirements organization comprise of human aspects for requirements engineering process by considering the six elements which are subject, object, tools, rules, community, and division of labor. The study has successfully captured the activity in context and thus shown the practicality of activity theory for analyzing

requirements. Thus, we have suggested the use of activity theory as an alternative for the requirements analysis process.

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