Compatibility of Problem Solving Theory and Activity Theory

Evaristo Kangwa
Mukuba University, P.O Box 20382, Kitwe, Zambia

***Abstract*: The paper reviews problem solving theory and activity theory in order to determine whether or not the two theories are compatibility. Both problem solving and activity theory have been extensively studies since their inception over 8 decades ago. While problem solving has been studied as a cognitive domain as well as a pedagogical domain, activity theory has been extensively studied as a theoretical framework to understand the relationship between subject and object in relation with other players within the system. Vygotsky observed that through mediating artifacts, humans have moved from lower to higher cognitive function. In this sense, activity theory may be used as a framework for studying the cognitive development of the subject. Having compared the two theories, a number of relations are identified that seem to exist on the conceptual level between the two theories. Among the relations identified include the following: Both problem-solving theory and activity theory seem to agree with the notion of solver or subject first identifying the existence of a problem or a need that requires changing or transforming; Both theories seem to suggest that tools or instruments, either physical or psychological, shape the activity and that the tools are used to accomplish the activity. It is therefore, important for future research to focus on the empirical evidence to confirm the compatibility of problem solving theory and activity theory.**

I. INTRODUCTION

There seems to be a thin line between problem solving theory and activity theory when viewed from the point of view of considering humans as actors who is always striving to overcome an obstacle or indeed striving to transform the current state to the goal state. at the conceptual level. Although both problem solving and activity theory are knowledge domains that have been extensively studied, there seem to be a paucity of studies that have focused on relationships between the two theories. Problem solving theory acknowledges the fact that problem solving is part and parcel of one's daily life (Uredi & Kosece, 2020), because everyday humans encounter and solve countless number of problems. While activity theory holds that humans have the needs which lead them to carry out activities to satisfy their needs (Babapour, Cabaleda-Cordero, & Karsson, 2021). But for one to embark on solving a problem there must be a need, which motivates the solve to do so. This piece work has attempted to demonstrate at the conceptual level the compatibility of problem solving theory and activity theory.

1.1 Theory Of Problem-Solving

Problem-solving in the educational arena has been a topic of discussion as early as 1940 (see, Polya, 1945). Literature, of the Theory of Problem Solving, is seemingly in agreement with the notion that problem-solving is a cognitive process in which the problem solver strives to solve the immediate problem (lumbelli, 2018, Alescio-Lautier et al., 2021). According to Alescio_lautier et al (2021) during problem solving, the interaction of divergent and convergent thinking supports the fluid engagement of the cognitive processes (p.4) In another sense, problem-solving is thought of as the cognitive processing to figure out a more suitable and effective means of reaching the goal (Dostal, 2015). Drawing on Dostal (2015)'s thoughts about the theory of problem-solving, the problem solver, who is the subject, is actively involved in devising ways to convert a problem from its current state to the desired state of which the solution method is not apparent to the solver. Three characteristics of problem-solving are identified, namely, (i) problem solving is cognitive, implying that it takes place internally in the mind; (ii) problem solving is a process because it involves manipulating knowledge representations; and, (iii) problem solving is directed, implying that it is motivated by the goal of the problem solver (Kirkley & Foshay, cited in, Dostal, 2015).

1.1.1 Problem

It is important to unpack the meaning of the concept problem. Literature seems to agree that a problem arises when a solver has a goal but does not immediately realize how to achieve it (Csapo & Funke, 2017; Dostal, 2015; Funke, 2010). The definition provided can be broken down into three components, namely, (i) the problem always begins in a given state referred to as the current state; (ii) the problem solver, who is a subject, desires to transform current or given state into the final or end state called the goal state (outcome); and, (iii) the problem solver has no immediate and effective way to achieve the goal, referred to as the barrier (tension, disturbance or conflict). Johnson (2000) also describes a problem as having two attributes. A problem is an unknown entity on one hand, and resolving the unknown must have some social, cultural or intellectual value that pushes someone to find the unknown (Johnson, 2000).

Dostal (2015) talks about a problem as, (i) an interactive relation between a subject and its environment, which incorporates the inner conflict that is resolved by the subject by searching for means to move from the initial condition to the final condition; (ii) the existence of conflict causes the dynamics of activity and, this further establishes a source of motivated activity, what Csapo and Funke (2017) call "problem situation (p. 61),"; (iii) during conflict resolution,

the subject exceeds something that is directly stated (Linhart, 1976, as cited in Dostal, 2015). Csapo and Funke (2017) describe the existence of a barrier between the problem solver's current knowledge and the desired result as a problem situation. The problem situation is the whole range of conditions that determine the creation and particulars of the problem (Csapo & Funke, 2017). When a subject (problem solver) encounters a problem, the willingness to resolve the problem from its current state to the desired state is very cardinal. In the educational field, in particular, the mathematics classroom, learners' willingness to accept the existence of a mathematical problem is cardinal in that learners may not be motivated to solve the problem unless they willingly accept it.

Problem situation has been defined as an impediment that the subject is fully aware of but needs to look for new knowledge, the new method and activities to overcome it (Csapo & Funke, 2017). Whereas Dostal (2015) explains that problematic situation includes circumstances and conditions that cause difficulty, conflict, unrest, feeling of uncertainty, limitation, or concern over the disorder, which can be material or non-material and can require operations with physical objects, things or thought operations (p. 2802). The existence of a problem always arises from a problematic situation. Therefore, every problem is tied to a problematic situation, although not every problematic situation culminates into a problem because that depends on the individual. Furthermore, when a person confronts a problematic situation and becomes aware of its existence, s/he has not seen the problem until the ability of problem awareness develops (Dostal, 2015). According to Dostal (2015), a person with the ability to recognize the existence of the problem will be able to specify the difficulty or the source of the conflict which causes the problematic situation and will be capable of dealing with the problem (p. 2800). On the other hand, the individual who does not recognize the existence of the problem, despite possessing the feeling of curiosity, does not realize what causes the difficulty, which obstacle causes the conflict to be removed, is not capable of resolving the problem (Dostal, 2015)

Funke (2010) states that a person's initial knowledge of the problem is the conditions (the given state); the operations are permissible activities that can be performed to achieve the required final state (outcome) with the help of available instruments (tools). Along the way to achieving the goal, obstacles have to be overcome. The process of overcoming the obstacle can include not only cognitive but also motivational and emotional aspects.

1.1.2 Collaborative problem solving

It is also possible that a problematic situation can occur to an individual who might share the situation with two or more subjects, who acknowledge the existence of the problematic situation, and who equally do not have immediate strategies to resolve the problem because if they do, then a problem does not exist. In this case, we speak of a group of subjects being fully aware of the existence of the problem and are willing to work together to resolve the problem, referred to as collaborative problem solving (OECD, 2017). According to OECD (2017), collaborative problem solving is the "capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and efforts required to come to a solution and pooling knowledge, skills, and efforts to reach that solution (p. 13). Thus, the effectiveness of collaborative problem solving depends on the ability of group members to collaborate and prioritize the success of the group over individual success.

Collaboration demands the interaction of two or more individuals. Collaboration has many definitions in the literature. More application to the context of this study is Csapo and Funke's (2017) definition, that collaboration is "an activity of working together towards a common goal" (p. 230). According to Csapo and Funke (2017), collaboration encompasses three elements, (1) communication, which involves the exchange of knowledge or opinions to achieve understanding by participants; (2) co-operation, which is primarily agreed-upon in terms of the division of labour. Co-operation also involves slight differences in responsive contributions to planning and problem analysis; and, (3) responsiveness, which refers to active and insightful participation (p. 230).

Csapo and Funke (2017) further explicate that collaborative problem solving involves both social and cognitive skills, which are divided into subskills. According to Csapo and Funke (2017), social skills are divided into three sub-skills, namely, participation, perspective-taking, and social regulation, while cognitive skills are divided into two sub-skills, namely, task regulation and knowledge construction (p.230).

In a nutshell, collaboration requires some kind of social interaction. However, social interaction in collaborative problem solving is not limited to sociability and face-to-face presence, the social and interaction aspects, rather, applies to individuals' preference to engaging in activities that involve others or that are intended to benefit others (Csapo & Funke, 2017). In this study, grade 10 mathematics classroom constituted learners that worked either individually or collaboratively with others, whose primary goal was to learn mathematics.

1.2 Activity Theory

Activity theory stems from the cultural-historical activity model that was developed by Russian cultural psychology (see, Engestrom, 1987). Vygotsky is accredited with the conceptualization of certain theory constructs, which are still widely applicable today, such as cultural mediation, the Zone of Proximal Development (ZPD), and natural and higher psychological functions (Allen, Karanasios & Slavova, 2011). As observed by Vygotsky, humans need mediating certain artifacts to move from lower to higher cognitive function (Allen, Karanasios & Slavova, 2011). Higher psychological/ mental functions are those that are socially initiated, culturally

arbitrated, and voluntary executed in terms of control and conscious realization of actions (Wertsch, 1985). Russian cultural psychology was introduced to help in understanding the interactions between humans and tools or material objects. According to Vygotsky (1978), humans are active agents in the process of development. Nonetheless, this development does not occur in a vacuum, in the sense that humans are social entities, and are always interacting with other humans in groups and communities, formed by culture, through mediating tools such as language (Allen, Karanasios & Slavova, 2011). Vygotsky and colleagues acknowledged that humans and their experiential world were always coevolving (Allen, Karanasios & Slavova, 2011). As humans act on objects in groups or communities, using culturally produced tools and artifacts, they transformed the tools, themselves as well as their environment.

Leont'ev (1978) has built on Vygotsky's work and introduced the idea of activity, in the context of human existence, which involves the purposeful transformation of nature and social reality (Davydov, 1999). According to Leont'ev (1978), an activity starts with a motive such as a need or a drive (as cited in, Karasavvidis, 2009). An activity consists of one or more actions, of which completion of actions satisfies the initial motive. In Leont'ev's Activity, all components are realized in specific contexts which determine, to a great extent, the condition under which the actions can be realized and the initial motive can be satisfied (Karasavvidis, 2009). Leont'ev differentiated the notions of activity and action, stating that humans participate in goal-directed actions, by using mediated tools even when the outcome may not be visible to them; in the long run, they derive the satisfaction of a need from actions through the achievement of the outcome. In the education field, particularly in mathematics classrooms, learners are engaged in many activities directed at solving problems, with the help of mediating tools which may be mental, for instance, cognitive strategies and physical such as symbols. By purposefully engaging learners in mathematical problem solving, they improve problem-solving skills and in the long run, their problem-solving abilities develop.

In short, mathematical activities in the classroom are necessary for cognitive development, and cognitive abilities develop as a result of the internationalization of actions with objects and other people and then externalization (Vermeulen, 2016; Kaptelinin, 2013).

Activity Theory has roots in Vygosky's (1978) notion that tools or mediating artifacts influenced human behaviour. According to Vygotsky (1978), human activity was purposeful and was accomplished by a set of actions through tools, which may be physical (pen and paper, calculator, etc.) or psychological (language, cognitive strategies, carrying out algorithms, etc.). Hasan and Kazlauskas (2014) described the relationship between the human doer (subject) and the activity being done (object) that form the core of activity (see, Figure 1).

In short, activity in the mathematics classroom is characterized by learners working on mathematics problem-solving tasks while teachers facilitate the learning of mathematical problem-solving using assessment techniques and problem-solving teaching approaches with the focus on the outcome of improving learners' problem-solving skills. This is exemplified in Figure 1.

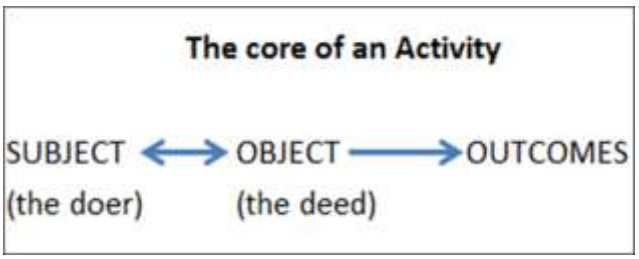

Figure 1: The core of an Activity (Adopted from Hasan and Kazlauskas, 2014)

In the model of the core of activity, the 'object' incorporates the purpose and focus of the activity, whereas the 'subject' may be a person or group of persons with different motives who are involved in the activity, with the view of achieving an 'outcome', which can be intended or unintended (Hasan & Kazlauskas, 2014). In a mathematics classroom, the core of activity happens to be learners 'doing a variety of problem-solving tasks' (the object or 'deed'). The subjects or 'doers' are learners and their teachers of mathematics who happen to bear different motives are involved in the activity to resolve the mathematics problems. The idea of embarking on an activity in a mathematics classroom is to improve problem-solving skills in learners so that consequently they become competent problem solvers (outcome). The core of activity, as described by Hasan and Kazlauskas (2014), implies that although learners and their teachers had different motives regarding engagement with mathematical tasks, they seemed to share a common goal, that of improving problem-solving skills in learners. What the core of activity seemed not to explain, however, was the fact that the mediating tools or artefacts had social, historical, and cultural aspects embedded in them and these influenced how the activity was accomplished.

Cultural-Historical Activity Theory (CHAT) emphases humans as agents of change within the context of history and culture; this is accomplished through actions with the help of tools, by either observing or breaking the rules implicitly and/ or overtly, working collaboratively or individually within a community whose efforts are directed toward tasks through explicit division of labour. In a mathematics classroom situation, grade 10 mathematics learners as agents of change are actively engaged in doing mathematical problem-solving tasks. Learners engage in solving mathematics problems with the help of tools such as language, mathematical symbols, and strategies to expand knowledge or lead to a new understanding for both individuals and groups. Every classroom has got rules. Therefore, learners in the mathematics classroom are expected to observe rules, for

instance, the use of mathematical symbols, language and algorithms, etc., some of which may be explicit, while others may be implicit. However, not all learners will observe the rules at the same time; a few learners might break them knowingly or unknowingly, for instance, failure to grasp a mathematical concept or use a strategy appropriately. Learners are sometimes allowed to work collaboratively with others or individually within the classroom to solve mathematics tasks by tapping into their different mathematical abilities through the division of labour.

1.2.1 Third generation of the activity theory

The third generation of AT or CHAT grew out from the first and second generations by formulating the conceptual tools to understand dialogue, numerous viewpoints, voices and networks (Pericleous, 2017). Engestrom (2001) clarified the perspectives of this model by expanding an activity system to include two interacting systems as a minimal unit of analysis. The model portrays an activity system interacting and overlapping with other activity systems. In the current study, mathematics classroom consisted of two interacting and overlapping activity systems, namely, the learners' activity system and the teacher's activity system. Although the immediate objects differ between the two activity systems, they share a common object, which is that of improving problem solving skills in learners. Between and within activity systems, tensions and contradictions are always present. The tensions and contradictions happen to be the basis of change or transformation (Engestrom, 2001). According to Engestrom (2001), an activity system comprises a group of individuals who have different views, traditions and interests. The division of labour distinguishes the roles and responsibilities of participants. Whereas participants hold different histories, the activity system carries several layers and components of history embedded in artifacts, rules, and agreements. The multiple points of view escalate as they enter into networks of interacting activity systems. The different views also serve as sources of conflict and sources of improvement through actions of interpretation and negotiation (Thorgeirsdottir, 2015). The activity system of CHAT's third-generation fully utilizes Leont'ev's notion of activity, actions, and operations as the focal point, which serves as the smallest unit of productive human behaviour (see, Roth, 2007). The model shown in Figure 3.4 is extended to illuminate two interacting activity systems as a minimum unit of analysis demonstrated in Figure 5.

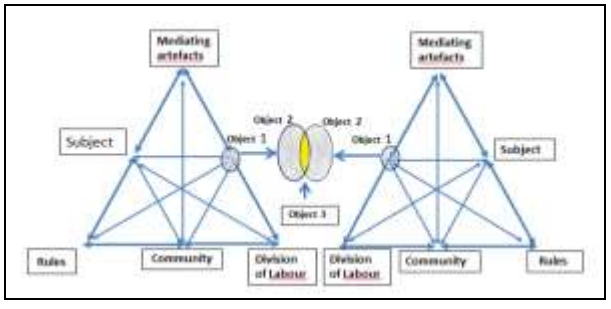

Figure 5: The third generation of CHAT (Hardman, 2015)

Engestrom (2001) described Cultural-Historical Activity theory using five principles, namely,

(i) the first principle, views activity system as the main unit of analysis in Activity Theory;
(ii) an activity system is often a community of multiple perspectives, likes and traditions, which in most cases, are the sources of conflict and change in the system. Usually, conflicts are escalated by the division of labour due to differences in constituent members of the communities who bring their assorted histories and that of the system itself, which is proliferated through artifacts, rules and conventions;
(iii) activity system does not develop or get transformed overnight; rather, it takes a long time to develop. The history carried by the activity system, which often remains engraved in older phases of activities helps to inform problems as potentials for development;
(iv) contradictions are central to the activity system because they can lead to tensions as well as transformations. Contradictions are structural tensions that grow over time within and between activity systems. They not only have the potential to cause disruptions and conflicts, but also innovations that can completely transform the activity; and, expansive learning is associated with the notion of expansive transformation, which is a long cyclic process of qualitative change or transformation in the activity system. As the multi-layered contradictions in an activity system increase, some individual participants become inquisitive and break away from the established norms. Expansive transformation happens to be the reconceptualization of the object and motive of the activity by accepting a radically wider range of possibilities than in the former mode of activity.

1.2.2 Generations of Activity Theory

The Activity Theory (AT) has undergone three stages of development, also referred to as the generations of Activity theory, and these could be conceptualized as the offspring of AT. The evolution of Activity Theory starts from the early works of Vygotsky and Luria (1978), and Leont'ev (1978) (cited in, Daniels & Guherrez, 2009; Engestrom, 2001; Harasim, 2012).

1.2.3 The first generation of the activity theory

Vygotsky and colleagues formulated the idea of mediation (Vygotsky, 1978; Leont'ev, & Luria, 1978). Mediation is the fundamental principle of the first generation of Activity Theory. Mediating tools include models, symbols, language, resources and strategies employed by learners and teachers. The concept of mediation that was developed by Vygotsky constituted two basic elements known as stimulus (S), depicting subject, and response (R) depicting object. The stimulus (subject) and response (object) are related by intermediary terms called mediating tools, which convey

inherent historical relationships (Kuuti, 1996). Subject transforms the object with the help of a mediating tool to produce an outcome. The grade 10 mathematics learners and their teachers, in the context of the first-generation, are using the mediating tools to accomplish problem-solving tasks. This model, unfortunately, does not have the room to explain the different roles the individual learners are performing, and this is shown in Figure 2.

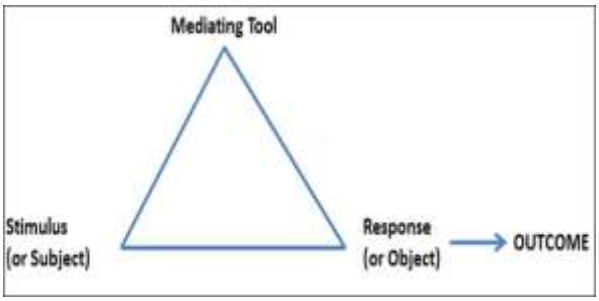

Figure 2: The first generation of activity theory (adopted from Said et al., 2014)

The implication of the model in Figure 2 is that when learners of mathematics are confronted with a mathematical problem, their thought is not simply a matter of response in reaction to a stimulus (Vygotsky, 1978), but thinking is inherently mediated by abstract symbols and physical objects, like language, tools, numbers, and signs. Thus, this model focuses on individuals' construction of knowledge rather than collectively. Therefore, the process of transformation shown in Figure 2 has some limitations, in the sense that the major unit of analysis happens at the individual level and lacks the element of collective activity (Said *et al*., 2014).

Leont'ev (1978) extended the notion of individual activity to a collective activity by incorporating the notions of 'community and 'division of labour' into Vygotsky's model (p. 59). Leont'ev's model was not presented graphically, but as a hierarchical activity structure (Nussbaumer, 2012). This structure does not only provide additional information about the cultural-historical traditions and experiences, but also the cognitive and physical processes involved. Leont'ev added various levels, which include activity-driven motive, action directed toward a goal, and operations determined by conditions and tools (Nussbaumer, 2012). According to Nussbaumer (2012), the hierarchical levels of activity can provide a framework to understand the relationships between activities, actions, operations and artefacts, motives and goals of subjects, and communities and contexts in which the activities are taking place as represented in Figure 3.

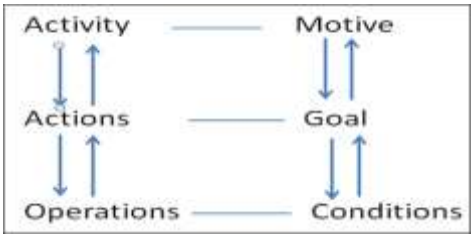

Figure 3: Activity, actions, and operations adopted from Nussbaumer (2012)

Borrowing from this model, it can be seen that activity, which could also be associated with learning mathematics, happens to be the prime activity in mathematics classrooms. This activity (learning mathematics) is at the top of the hierarchy in Figure 3, goal-directed actions (solving mathematics tasks), and key operations (carrying out the strategies and algorithms). Hasan and Kazlauskas (2014) have argued that the activity must be construed from the perspective of its cultural and historical environment. The authors contend that an activity mediates and is mediated by the physical (e.g., pen and paper), and psychological (e.g., strategies, language) tools employed in the social context (the mathematics classroom) where the activity is happening (Hasan & Kazlauskas, 2014). Activity will take place in so far as the subjects are motivated by taking part in the activity.

1.2.4 Second generation of the activity theory

The second generation of Activity Theory is associated with Engestrom (1987). Leont'ev's (1978) version of activity theory "never graphically expanded Vygotsky's original model of a collective activity system" (Engestrom, 1999, p. 5). Although Leont've explicitly mentioned the collective nature of human activities, the author did not explore the structure and development of collective activities; neither did he propose a conceptual model for them (Kaptelinin & Nardi, 2006). Therefore, Engestrom proposed a model of collective activity by, (1) adding in the subject-object activity a third component called community; and, (2) proposing mediation relationship of each of the three components, as follows; tools mediate subject-object interaction, rules mediate subject-community interaction, division of labour mediate community-object interaction and finally added the outcome, the intended result (Kaptelinin & Nardi, 2006). The author enriched Activity Theory by stressing the interaction of an individual with the social world through artefacts as mediating tools, in the environments where activities were produced (Engestrom, 1987). Engestrom incorporated the ideas of subject-object, tool mediated relation in the first generation of the CHAT that gives recognition to the inter-relationships between the individual and the community, context, history, and the collaborations of the situation and activity (Engestrom, 1987).

In Engestrom (1987)'s second-generation Activity Theory, the subject is the individual or group of individuals engaged in the activity, whose participation in the activity is motivated by the object. The subjects use mediating artefacts, which serve as physical and psychological tools to transform the object. Subjects who are learners and the teachers of mathematics belong to the social and cultural group called community, whose behaviour is regulated by the rules and social norms (Roth, Radford & Lacroix, 2012). The division of labour indicates the distribution of roles and responsibilities among subjects as they engage in a task (Cole & Engestrom, 1993). Said *et al.* (2014) posit that Engestrom's triangular model is made up of the outer triangle and the inner triangle that are overlapping. The outer triangle of the triangular model, also known as the external triangle, contains elements of tools,

rules, and division of labour, whereas the inner triangle, also referred to as the internal triangle, constitutes the elements of the subject, object, and community.

The systematic and interrelationship between the components of an external triangle and internal triangle are mutual. For instance, the tools negotiate the relationship between subject and object, while the relationship between the subject and community is negotiated by the rules and norms; the relationship between object and community is mediated by division of labour (Said *et al*., 2014). In other words, the vertices (components) of the external triangle are mediating factors of the relationship between vertices (components) of the internal triangle as typified in Figure 4.

In the context of mathematics classroom, learners and teachers are the subjects whose immediate objects differ but share long term object that of improving learners' problem-solving skills. The second generation of activity theory has a limitation because it what the object of different subjects is taken care of. In this case, teacher's immediate object is different from the immediate object of learners. Therefore, second generation activity theory fails explain a situation when the subjects have unique objects as drivers of changes. The graphical representation of the second-generation activity theory is presented in Figure 4.

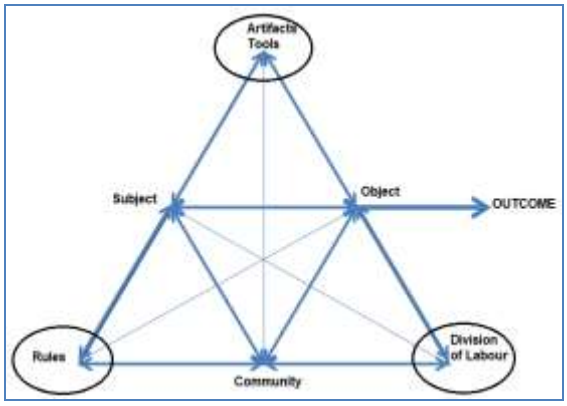

Figure 4: Second generation of CHAT (Engestrom, 1987)

Compatibility of problem-solving theory and activity theory

In this section, the researcher attempts to demonstrate that the Activity Theory as a theoretical framework that was advocated in the present study is compatible with Problem Solving Theory. The histories of both problem-solving theory and activity theory date way back to around the same time. Whilst problem-solving theory emerged in the early 1940s, activity theory started in the 1930s. Since then, the two theoretical domains have been extensively studied. Problem-solving has been studied as a cognitive domain (for examples, see, Christou & Papageorgiou, 2007; Kuchemann & Hoyle, 2005) as well as a pedagogical domain (see, Schoenfeld, 2013; VanLehn *et al*., 2004), whereas, activity theory has been studied as a framework to view the relationships between subject and object in relation with other players (Engestrom, 2002). However, Vygotsky (1978) observed that through mediating artefacts, humans move from lower to higher cognitive function. In this sense, activity theory may be used as a framework for studying the cognitive development of subjects.

In literature, it is noted that activity theory examines learning as a social practice and activity (Engestrom, 2000) and can be applied in practice. Therefore, activity theory suggests a relationship between theory and practice emerging in the historical and cultural context (Vermuelen *et al*., 2016). This implies that whatever activity is carried out by the subject, it is embroiled in historical as well as cultural perspectives because the mediating tools or artefacts carry with them the historical and cultural aspects. Similarly, the problem-solving theory seems to recognise the historical and cultural aspects prevalent in local contexts (see, Lave, 1990). The author wrote that the success of interaction between students and the mathematics that they were learning was achieved by incorporating social and cultural aspects trending in their local environments (Lave, 1990). This idea resonates with Jonasson's (2000) contribution concerning overcoming a problematic situation, the difference between a goal state and current state, that the problem must have some social, cultural, or intellectual value (see, Section 1.1.1). Therefore, both activity theory and problem-solving theory seem to subscribe to the notion that humans are entrenched in the culture, and everything people do is shaped by and draws upon their cultural values and resources.

In Section 1.1, three characteristics of problem-solving have been identified, demonstrating that problem-solving is cognitive, problem-solving is a process and that problem-solving is directed by the goals of the problem solver (Dostal, 2015). In Section 1.1.1 it was discussed that a problem arises when a solver or subject has a goal but does not realise how to achieve it (see, also, Csapo & Funke, 2017; Dostal, 2015; Funke, 2010). The notion of goal-directed activity can also be observed in the activity theory. Activity theory espouses that an activity is a "collective action propelled by the object" (Leont'ev, 1978, p. 59). The focus of the activity is the object, which is achieved through individual actions driven by goals. What seems to associate problem-solving theory with activity theory is the idea that the subject (solver) is motivated to embark on an activity by the desire to transform the current state (object) into the desired goal state (outcome). Problem-solving theory talks about a solver acknowledging the existence of a problem, which Csapo and Funke (2017) refer to as a barrier. A problem always starts in a given state or current state, which the solver desires to transform into the goal state with the help of tools or instruments, which can either be psychological or physical (Funke, 2010). While activity theory contends that activity does not exist without a reason (Leont've, 1978), rather human activity is directed by an object or motive, which arises from human needs. It is understood that the object or motive can be material or ideal, present in perception or exclusively in imagination or thought (Bakhust, 2007).

The concept of mediation that was developed by Vygotsky constituted two basic elements known as stimulus (S), depicting subject and response (R), depicting object (Vygotsky, 1978). The subject and object are related by mediating tools (Kuuti, 1996). Subjects transform the object with the help of mediating tools to produce an outcome. Like activity theory, Funke (2010) describes the relationship between a person's initial knowledge of the problem as conditions or given state; the operations are the permissible actions that can be performed to achieve the desired goal (outcome) with the help of available instruments (mediating tools). Along the way to achieving the goal, obstacles have to be overcome. The researcher suggests that it is possible to relate Vygotsky's First-generation mediated activity to Funke's (2010) problem situation that connects the solver's current state with the goal state, where tools are implicated in overcoming the barrier. In both cases, human activity is mediated by tools as they transform the current state or object to the goal state or outcome. The graphical representations of the accomplishment of activity at the individual level are given in Figure 6.

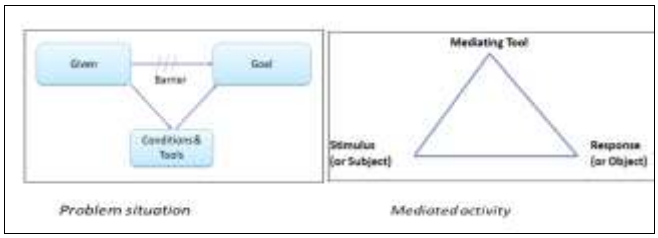

Figure 6: Graphical model of first-generation activity theory and problem situation

The extension of individual activity by Leont've (1978) to collective activity by adding notions of community and division of labour to Vygotsky's model (see, Section 1.2.2; see, also Section 1.2.3) gave rise to collective mediated activity (Kaptelinin & Nardi, 2006). What this means is that instead of subjects embarking on an activity individually; the community who have shared interest or need to collectively transforms the object into outcome (Engestrom, 1999). As members of the community are involved in the activity, their process of participating in the activity results in the mutual transformation of themselves and objects. Comparable to the aspect of collective activity system of activity theory is the notion of collaborative problem solving (OECD, 2017) in the problem-solving theory. Collaborative problem-solving permits two or more subjects to work together on an activity to get the desired goal (see, Section 1.1.2).

Lastly, the researcher presents a summary of suggested points where activity theory and problem-solving theory seem to be compatible.

1. Both problem-solving theory and activity theory seem to agree with the notion of solver or subject first identifying the existence of a problem or a need that requires changing or transforming;
2. Both theories seem to suggest that tools or instruments, either physical or psychological, shape the activity and that the tools are used to accomplish the activity;
3. The object or problem space is the focus of the activity, in other words, both in activity theory and in problem-solving theory to change the status quo there must be a drive or motive necessitating change;
4. In activity theory, environmental surroundings and past experiences influence the kind of unconscious actions that depend upon conditions chosen by the subject to carry out an activity (Bakhust, 2007). While problem-solving stresses that a solver's prior experience and knowledge of the context plays an important role in problem resolution;
5. In activity theory, a goal-directed action may become routine as actions become automatic operations through becoming familiar with or competent in the action (see Nunez, 2009). This is also true with problem-solving; a problem ceases to be a problem if the solver becomes familiar with it or indeed after the problem resolution;
6. Activity theory and problem-solving theory seem to be in agreement that contradictions or barriers also considered as conflicts, tensions, clashes and disturbances (Basharina, 2007; Berge & Fjuk, 2006; Dippe, 2006), problems, ruptures, breakdowns, misfits (Kuutti, 1996), are overcome through the resolution of conflicts. Contradictions or barriers may either permit learning or impede it, depending on the extent to which they are recognised and resolved (Nelson, 2002). contradictions may also be considered as sources of change and development (Engestrom, 2001, p. 137); and,
7. A key premise of activity theory is that individuals and collectives create and access mediating instruments to stimulate change within themselves and to their context. Problem-solving postulates that collaborative problem solving is the "capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and efforts required to come to a solution and pooling knowledge, skills, and efforts to reach that solution" (OECD, 2017, p. 13).

II. CONCLUSION

Although the relationship between problem solving theory and activity theory has not been confirmed empirically, there are a number of aspects on the conceptual ground that seem to suggest that the two theories can be related on a one-to-one correspondence. For instance, both theories were developed about the same time, the early late 1930s and both problem-solving theory and activity theory seem to agree with the notion of solver or subject first acknowledging the existence of a problem or a need that requires changing or transforming as well as many other aspects identified in the previous section. Therefore, suffice to say that the two theories are compatible. However, future research should focus on a more

critical analysis of the compatibility of the two theories by providing some empirical evidence.

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