Enhancing Personalization and Learner Engagement in Context-aware Learning Environment

A Pedagogical and Technological Perspective

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Dedicated

to my parents Gabriel Mayeku and Florence Mayeku and to my siblings

for their endless love, support and encouragement.

Dedicated also to those who

in their quest for knowledge have lost their lives.

Especially to families of Garissa University students

who were brutally murdered by terrorists.

Abstract

Context-aware technologies promise great potential in technology enhanced learning (TEL). However, as transformation arises in educational set up as a result of the use of context-aware technologies, so is the challenge emerging of applying sound pedagogical foundation when employing these technologies. Furthermore, despite the fact that context-aware systems offer potential to cater for different learners' needs, how to provide a learning experience tailored to each learner's needs in an extremely diverse and rich environment still poses a challenge. In addition, although the notion of adaptation as utilized by context-aware technologies enhances learning experience, it has also been criticized for the lack of learner involvement which is a crucial component in achieving effective learning.

In an attempt to address these challenges, the first goal of this study was to formulate a pedagogical framework that could offer a platform for the integration of pedagogy and technology in a context-aware learning environment (CALE). The second goal was to enhance personalization by exploring the internal dimensional context. In particular, the study examined the use of learning preferences as context. The scope of personalization covered in this thesis was on social personalization. Specifically, learners' sociological preferences were considered as a basis for achieving social personalization. The third goal was to enhance learner engagement at both individual level and in a collaborative environment. In order to achieve this, context-aware recommendation approach was explored with the aim of involving learners through decision making. Social personalization and small-group collaborative learning approach were investigated. Specifically, sociological preference similarity strategy was used as a basis for group formation. Another method used was structuring the learning activity flow based on Kolb's experiential learning model with an extension on the active experimentation phase. This approach was intended to ensure learner involvement at both individual and collaborative level. The fourth goal of the study was to implement a personalized and engaging context-aware learning environment (PECALE). PECALE was implemented within the CALE pedagogical framework formulated in the first goal. The results of the experiment showed that the study's approach had a positive impact on learner engagement in terms of learner participation, individual performance and group performance.

This work and its findings may provide useful insights for conducting further research in the area of context-aware learning, personalized learning, learner engagement, small-group collaborative learning and group composition. The CALE pedagogical framework developed may be significant to developers of CALEs and instructors who use these environments.

Zusammenfassung

Kontextsensitive Technologien bieten ein vielversprechendes Potenzial für den Einsatz im Bereich des technologieunterstützten Lernens (TEL). Während das Bildungssystem durch diese Technologien einen Wandel erfährt, besteht die Herausforderung darin, diese auf der Basis einer soliden pädagogische Grundlage anzuwenden. Obwohl kontextsensitive Systeme das Potenzial bieten auf die unterschiedlichen Bedürfnisse des Lernenden einzugehen, besteht die Herausforderung darin, eine Lernerfahrung zu schaffen, welche auf den jeweiligen Lernenden in seiner vielfältigen und reichhaltigen Umgebung zugeschnitten ist. Zusätzlich, obwohl das Konzept der Anpassbarkeit, wie es in kontextsensitiven Technologien genutzt wird, die Lernerfahrung verbessert, steht es aufgrund des Mangels bei der Einbeziehung des Lernenden – welches eine entscheidende Komponente für effektives Lernen darstellt – in der Kritik.

In einem Versuch, diese Herausforderungen anzugehen, war das erste Ziel dieser Dissertation, ein pädagogisches Rahmenwerk zu schaffen, welches eine Plattform für die Integration von Pädagogik und Technologie in einer kontextbezogenen Lernumgebung (CALE) bietet. Das zweite Ziel war es, die Personalisierung zu verbessern, indem der interne dimensionale Kontext erforscht wurde. Insbesondere untersuchte die Dissertation die Verwendung von Lernpräferenzen als Kontext. Der Bereich der Personalisierung, welcher in dieser Arbeit betrachtet wurde, konzentriert sich dabei auf die soziale Personalisierung. Insbesondere wurden die soziologischen Präferenzen des Lernenden als Grundlage für die Verwirklichung sozialer Personalisierung berücksichtigt. Das dritte Ziel war es, das Engagement des Lernenden in der individuellen sowie kollaborativen Umgebung zu verbessern. Um dies zu erreichen, wurde ein kontextsensitiver Empfehlungsansatz erforscht, mit dem Ziel die Lernenden durch ihre Entscheidungsfindungen mit einzubeziehen. Hierbei wurden die soziale Personalisierung und ein kooperativer Kleingruppenansatz untersucht. Insbesondere wurde als Grundlage für die Gruppenbildung eine Strategie gewählt, welche die Ähnlichkeiten der soziologischen Präferenzen berücksichtigt. Eine weitere Methode war, den Fluss der Lernaktivität anhand von Kolbs erfahrungsorientiertem Lern-Modell mit einer Erweiterung bezüglich der aktiven Experimentierphase, zu strukturieren. Dieser Ansatz sollte die Beteiligung des Lernenden sowohl auf individueller als auch auf kollaborativer Ebene gewährleisten. Das vierte Ziel der Dissertation war die Implementierung einer personalisierten und engagierenden kontextsensitiven Lernumgebung (PECALE). PECALE wurde innerhalb des pädagogischen Rahmenwerks CALE implementiert, so wie im ersten Ziel gefordert. Die Ergebnisse des Experiments zeigten, dass die Herangehensweise der Studie einen positiven Einfluss auf das Engagement des Lernenden in Bezug auf die Lernbeteiligung, die individuelle Leistung und die Gruppenleistung hatte.

Diese Arbeit und ihre Ergebnisse stellen nützliche Erkenntnisse bereit für die Durchführung weiterer Forschung im Bereich des kontextsensitiven Lernens, des personalisierten Lernens, des Lern-Engagements, des kollaborativen Kleingruppen-Lernens und der Lerngruppengestaltung. Das entwickelte pädagogische Rahmenwerk CALE könnte bedeutsam für Entwickler von CALEs und Lehrenden sein, welche jene Lernumgebungen verwenden.

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To God be all the glory! He makes all things beautiful in His time. He is faithful to all His promises.

Contents

Chapter 1

1 Introduction

Education has undergone great changes in the last decades under the significant advancements in technology. With these advancements and increasingly widespread access to technology, its application in learning has become a consistent presence at all levels of education. Notably, with the increasing use of mobile and wireless technology, the use of context-aware technologies is gaining much popularity in Technology Enhanced Learning (TEL). The influence of these technologies in learning is now irrefutable. They have transformed the traditional concept of learning so that we are being frequently surrounded by and immersed in learning experiences. The assimilation of context-awareness technologies in learning has led to a major leap forward in TEL as well as impacted the growth and changing paradigm in TEL – (In this study, TEL is used to describe the application of information and communication technologies to teaching and learning [1]).

1.1 Background and Motivation

Context-awareness is proposed as an essential component of pervasive and ubiquitous computing (PUC). PUC research has strong focus on the seamlessness of technology, i.e., the technology should be immersed into daily life that people do not even notice it [2]. As a result, the concept of context-awareness has emerged. Context is defined by [3] as any information that can be used to characterize the situation of an entity. An entity in this case is a person, place, or object that is considered relevant to the interaction between the users and application, including location, time, activities, and the preferences of each entity [3].

In the field of TEL, context has been defined as the current situation of a person related to a learning activity [4]. The ability for the applications and services to use context information is what is referred to as context-awareness.

The goal of context-aware systems is to utilize contexts to ease a user's tasks and hence fulfill their needs [5]. According to [6], context and context-awareness provide a PUC environment with the ability to adapt the services or information it provides by implicitly deriving the user's needs from the context that surrounds the user at any point in time. In other words, instead of requesting the user to instruct the system to perform a task, the system carries out this task automatically and in a timely manner based on the current situation and conditions of the user and their environment. Therefore, the system needs to have the capability to recognize and understand the situation and conditions – and such capabilities can be best described as *awareness* [5, 7]. It is the ability to implicitly sense and automatically derive the user's needs that separates context-aware applications from more traditionally designed applications [6].

Context-aware systems promise great potential in TEL. They provide immense possibilities to adapt the learning spaces to different contexts of use hence capable to cater for different learners' needs. Context-aware learning environment has also the capability to explore the potential of the new flexible and cost-effective mobile platforms [4]. This makes it a suitable solution to postsecondary education's access and cost challenges. It also holds the potential to provide learners with personalized learning experiences in real-world situations [4]. This is because context-aware learning environment has the capability to integrate real and virtual learning environments. It can also provide an adequate environment with cognitive apprenticeships including features like situated learning, scaffolding among others. Additionally, it has the potential as argued by [8] to move e-learning and m-learning a step further from learning at any time anywhere to be at the right time and right place with right learning resources and right learning peers. Other features and potential benefits of context-awareness capability in a learning environment as cited by several researchers include the creation of a dynamic and integrated system for learning and the provision of more adaptive learning supports [9, 4]. Therefore, it is worthy to acknowledge that indeed context-aware technologies promise vast potential to offer great innovations in the delivery of education. It is important for researchers to explore these capabilities to achieve effective learning in TEL environment.

1.2 Problem Overview

The attributes that normally characterize context-aware technologies i.e. dynamism, heterogeneous and the mobility, have transformed the learning environment. However, as emerging trends and transformation arise in TEL as a result of these technologies, so is the challenge emerging of understanding and applying solid pedagogical foundation when using these technologies for effective learning. It is imperative that pedagogy continues to transform and evolve as technologies changes [10]. As [11] states, one of the most serious issue faced by emerging TEL environments is the lack of a solid theoretical framework which can guide effective instructional design and evaluate the quality of programs that rely significantly on the technologies used. Naidoo in [10] also argued that one of the main issues in applying these technologies in creating new models of TEL is not technical, but social because of insufficient understanding of pedagogical application outside the classroom. Therefore it is clear that a comprehensive, inclusive framework is needed in applying sound pedagogical foundation when applying context-aware technologies for effective learning.

Furthermore, though context-aware systems offer potential to cater for different learners' needs since they can adapt the learning spaces to different contexts of use, however, how to offer a learning experience that meets learners' individual needs in an extremely diverse and rich environment has been a daunting task. This is not only because learners exhibit a wide range of diverse individual differences in learning needs, but also, amidst the changing paradigm, massiveness has become currently an essential feature of TEL environments. This has been clearly demonstrated in MOOC (Massive Open Online Courses) platforms. Furthermore, the diversity aspects have even been further broadened due the mobility, dynamism and heterogeneity characteristics of context-aware technologies. The technology the leaners use and the surrounding they may be in during the learning process may differ from learner to learner. Therefore the context in which learning occurs varies greatly among learners in that, apart from the diversity in the personal attributes of these learners, their work is distributed in time and place. In addition, nowadays, there is also diverse and overwhelming resources available for learners to choose from. Therefore, the identification and retrieval of suitable resources for individual learners based on their needs is vital.

Moreover, most of the current context-aware applications tend to focus on the external dimension of context. While, this has resulted in some interesting, and useful applications, these approaches generally do not provide support for more cognitive activities. Cognitive context information as noted by [5] is key in satisfying user needs since it provides personalized context-aware computing services. To extend context-aware application into more cognitive domains, such as information retrieval, decision making among others as [6] notes, the internal dimension of context like users preferences, goals, tasks, emotional state among others needs to be captured.

Besides, the notion of adaptation in context-aware systems has raised some concerns about its competence in achieving effective learning in a diverse environment. There have been voices of skepticism for example from [12] who argues that adaptive learning contents are not suitable to study because e-learning systems do not take into account their various contextual diversities and [2] who also argues that software intelligence remains insufficient to enumerate and address all eventualities.

Moreover, though adaptation has widely been proposed as an approach that can provide learning experiences that are tailored to learners' particular needs [9, 4], however, a concern that has been raised when using this approach is the lack of learner involvement. Adaptation aims at enhancing the learner experience by enabling entities in the user's environment to intelligently adapt to the active situation without any end-user involvement [13, 14, 15]. However, absolute machine control as manifested by employing adaptation approach is not always desirable considering the intellectual characteristics of the end-users [2]. Furthermore, not involving learners in controlling their own academic experiences is not always desirable in achieving effective learning. Conceptual literature suggest that learner engagement is one of crucial elements for the successful realization of learning that is satisfactory to the learner [16]. It has been argued to be an intrinsic part of learning [17]. Meeting the needs of learners and an understanding of the most effective ways to engage the learner result in a more satisfying and positive experience of learning, along with improved success [16].

Additionally, learner engagement is not only on individual basis but it is vital when groups of students work together to attain educational goals otherwise referred to as collaborative learning. Social integration has been found to be an important determinant for persistence [18, 19] in TEL. Learner participation in collaborative activities in TEL environments like online learning influences learning outcomes, learner satisfaction and retention rates positively [17, 19]. However, despite the advancement of technologies that support social presence, ensuring learner participation and achieving quality engagement in collaborative

TEL environments still poses a challenge as noted by several studies. Furthermore, despite the potential of context-awareness application, the focus of external context in the studies has left a big gap in exploring sociological context of the learner in enhancing social personalization. Social personalization offers a platform in enhancing learner engagement in collaborative learning environment.

In summary, though context-aware technology promises great potential in TEL, there are still concerns in achieving effective learning environment when applying these technologies. They include:

a) Pedagogical challenge i.e. the challenge of understanding and applying sound pedagogical foundation in employing context-aware technologies for effective learning
b) Diversity challenge in terms of individual differences in learning needs, diverse and rich environment in which learning occurs due to heterogeneity characteristics of context-aware technologies and overwhelming resources available for the learner to choose from
c) Limited exploration of internal dimension of context to support cognitive activities and provide more personalized learning
d) Learner engagement challenge, in that:
   - Though the adaptation approach utilized by context-aware technologies enhances learning experience, it limits learner involvement which is a crucial component in achieving effective learning
   - Due to the focus on external context in context-aware applications, sociological context – which promises great potential in enhancing learner engagement in collaborative learning environment – has not been explored

Needless to say that amidst the diversity in learner needs and environment in which learning takes place, there is a need for an efficient approach. An approach that taps into the full potential context-aware technologies offer with the aim of satisfying learner needs. One that provides personalized context-aware services and ensures that learners are actively involved in their learning at both individual level and collaboratively. Above all, all these should be achieved on a sound pedagogical foundation in order to ensure effective learning.

1.3 Research Goals

In an attempt to address the challenges mentioned above, the main study aimed at achieving the following goals:

a) To formulate a framework as a platform for integrating pedagogy and technology in context-aware learning environment (CALE).
   - This goal was to address the challenge of applying sound pedagogical foundation in CALE
b) To enhance personalization through consideration of internal context by specifically examining how learning preferences as context in which learning occurs can enhance personalized learning.
   - The nation of personalization was explored in this study in attempt to address the diversity challenge. The consideration of learning preferences was aimed at utilizing internal context in order to enhance personalization.
c) To enhance learner engagement at both individual level and in a collaborative CALE. The study was specifically aimed at:
   i. Exploring context-aware recommendation process in enhancing learner engagement through decision making.
   ii. Exploring social personalization in enhancing learner engagement in a small group collaborative CALE.
d) To implement a Personalized and Engaging Context-aware Learning Environment (PECALE).
   - PECALE was to be designed with the aim of enhancing personalization and learner engagement through context-awareness. It was to be implemented within the framework formulated in objective (a). The approaches for enhancing personalization and learner engagement were to be derived from the results of objectives (b) and (c).
e) To evaluate PECALE

1.4 Contributions and Significance of the Study

In view of achieving the objectives of this study, the following may be considered the study's main contributions. They include the formulation of context-aware learning environment (CALE) pedagogical framework, establishment of approaches that can be applied to enhance personalization and learner engagement in a CALE, and the implementation of a personalized and engaging context-aware learning environment (PECALE) software tool.

Formulation of CALE Pedagogical Framework

CALE pedagogical framework was formulated to offer a platform for the integration of pedagogy and technology in a CALE. The framework may be significant to designers and developers of CALEs and instructors who use these environments because it provides a guideline on how best CALE can be rooted in a sound pedagogical foundation. One of the advantage of CALE framework is that it provides the possibility to consider various dimensions of context. However, it also allows one to focus on either one aspect of contextual information (like the learner's sociological preference as it was in this study's case) or several contextual information and dimensions combined. This attribute makes it to be an ideal framework within which any context-aware learning environment considering any contextual dimension can be implemented. Furthermore this attribute may enable developers of CALEs to carefully implement one contextual aspect at a time when using this framework.

Approaches for Enhancing Personalization and Learner Engagement in CALE

The study also proposes approaches that can be applied as guidelines in enhancing personalization and learner engagement in CALE. One of the study's unique approach was the consideration of leaning preferences as context when designing a CALE. Considering learning preferences provides conditions that optimize learning for each learner making it an important key for reaching diverse individual learner needs. This in turn provides personalized services thus satisfying personal needs. The second approach applied by the study was the use of *Sociological Preference Similarity Strategy* as a basis for group formation. This strategy was used to enhance leaner engagement and performance within groups. The approach provides a platform to integrate the main four learning group assignment criteria i.e. Random assignment, Self-selection, Specific criteria and Task appointment hence making it possible to address different aspects of group assignment. The approach also makes it possible to address both homogenous and heterogeneous aspects of the group members. The third strategy employed in the study was context-aware recommendation with the aim of involving learners through decision making. The fourth approach applied was structuring the learning activity flow based on Kolb's experiential learning model with an extension on the active experimentation phase. This offers a platform in which learners, apart from being actively engaged, are able to achieve goals individually and collaboratively. The study's approaches may be significant to educationist using CALE, CALE developers and may also be of benefit to researchers in the field of personalized learning, learner engagement and collaborative learning.

Implementation of PECALE

Another main contribution of the study was the implementation of PECALE software prototype. It was developed with the aim of enhancing personalization and learner engagement. The tool was also designed with the intension of being integrated in a learning management system (LMS). In this study, it was integrated in Canvas Instructure LMS. As its main output, the tool recommends learning activity and assigns collaborative partners based on the learners' contextual information which in this case was the learners' sociological preferences. It allows the teacher to create various tasks that can be performed by learners with different sociological preferences as well as create tasks that can enable a learner to achieve goals both individually and collaboratively. The teacher can also monitor learner behavior in terms of participation, sociological preference and progress. Additionally, learners are able to choose a learning activity that best fits their preference and they are also allowed to give feedback. The learning activities have a known standard of completion. This tool may be significant to instructors who would like to cater for learners with different sociological learning preferences as well as engage learners in the learning process. It may also be used by instructors to form effective groups when employing small group collaborative learning approach in their teaching. Furthermore, instructors can make informed decisions that addresses individual learners' needs by monitoring learners' behavior. The tool can also be used as a plug-in in an existing LMS in order to apply its specific attributes.

In general, this work and its findings may be considered a special contribution in terms of providing some useful insights for conducting research in the area of context-aware learning, personalized learning, learner engagement, small-group collaborative learning and group composition.

1.5 Outline

This thesis is organized into five chapters. *Chapter 2* provides literature review related to the current study. It is organized in three sections. The first section examines the integration of pedagogy and technology with a focus on pedagogy. The second section reviews the state of the art of context-awareness technology in educational set-up with a focus on how learners' diversity challenge has been addressed. The last section discusses approaches that have been used to achieve learner engagement.

Chapter 3 presents the study's approaches in achieving its goals as follows: first, the formulation of the framework for integrating technology and pedagogy in CALE is explained, followed by the discussion on approaches applied by the study to enhance personalization and learner engagement within the formulated CALE pedagogical framework, and lastly, the implementation of (PECALE) software tool is presented.

Chapter 4 discusses the evaluation of PECALE. The experimental design, experimental set-up, results and the discussion of the study's results are presented. *Chapter 5* concludes the study and gives an outlook on the future work.

Chapter 2

2 Pedagogy and Technology; Context-awareness; Learner Engagement – *State of the Art*

This Chapter reviews literature related to this study. It is organized in 3 sections. The first section examines the concept of integrating pedagogy and technology with a focus on pedagogy. The existing learning theories and frameworks are reviewed to provide an understanding on sound pedagogical practices. The concept of distance learning (DL) in TEL is also discussed with a focus on learner attrition as well as a review of DL theories and frameworks is presented. The section also gives an overview on personalized approach to learning. The second section examines the state of the art in context-awareness technology in educational set-up. It particularly focuses on how the learner diversity challenge has been addressed. The last section reviews some of the approaches that have been used to address learner engagement challenge. An overview on recommender systems in TEL is presented. The sections also examines collaborative learning with a focus on small-group collaborative learning approach.

2.1 Pedagogy in Technology Enhanced Learning

As technology advances and transforms the world, the educational sector has not been left behind either. TEL is being extensively used in the educational world in both On-Campus and DL environments. Though the term TEL does not have explicit or a commonly accepted precise definition, however according to [1] the term TEL is used to describe the application of information and communication technologies to teaching and learning. According to

[20], TEL and e-learning can be used interchangeably to describe the broad approach to using technology to support teaching and learning processes, design and delivery. However, [21] claim that what makes TEL different from other terms like e-learning, TEL implies a value judgement: the word "enhancement" suggests an improvement or betterment in some way.

The use of technology for learning and teaching brings optimism and opportunity for education. Nonetheless, as [21] notes, it also challenges us to consider the best possible uses of that technology for students and, more fundamentally, educators' actions in the process of exploiting technology for pedagogical advantage. In order to achieve effective learning in TEL, pedagogy (thus the collected practices, processes, strategies, procedures and methods of teaching and learning [10]), has to be properly integrated with technology. Some educators as noted by [22] pride themselves on being pedagogically (as opposed to technologically) driven in their teaching and learning designs. On the other hand, some technologists put too much faith in the technologies, as though they alone could determine the effectiveness of TEL. However, effective TEL requires the right union of these components. Writing about the two (i.e. technology & pedagogy), [22] describes them as being intertwined in a dance: the technology sets the beat and creates the music, while the pedagogy defines the moves. They further explain that some technologies may embody pedagogies, thereby hardening them, and it is at that point that they, of necessity, become far more influential in a learning design, the leaders of the dance rather than the partners. Karsenti and colleagues [23] affirm this by noting that some factors, such as access and appeal, do not rely entirely on the educator, but must be facilitated by a technical support team, while the interaction factors must be implemented jointly by educators and the technical team. Therefore in order to achieve quality education while tapping into the full potential technology offers, there is need for these two components to be perfectly integrated.

2.1.1 Fundamentals of Sound Pedagogical Foundation

Learning is a complex practice [24]. Since this process continually changes depending on a person's experiences and surroundings, instructional designers and educators face a demanding task when producing meaningful and challenging learning experiences for all learners [25]. How the content is delivered thus pedagogy has always been a major concern in any learning environment since it is the cornerstone of effective learning. Over the years, a huge effort has been made to offer guidelines in ensuring solid pedagogical foundation in achieving effective learning. This has resulted into the formulation of learning theories and frameworks. According to [24], a theory provides the understanding necessary to take effective action. It also provides people with an explanation to make sense of complex practices and phenomena [24]. It offers a perspective that reduces complexity while suggesting generalizability [25]. Frameworks on the other hand provide a conceptual structure to serve as a support or guide for building an effective learning environment. In this section, existing learning theories and the instructional framework that have proved to be the basis for sound educational practices are examined in order to motivate the formulation of a pedagogical framework for a context-aware learning environment (CALE).

Learning Theories

Learning theories pertain to the learner oriented reason on how they learn in the way they do such as the learning styles, habits among others. In this section, the study takes a look at the perspectives of some of the old dominant theories to learning that still have great influence on teaching and learning in the present age. They include Behaviorism, cognitivism, and constructivism. The study further looks at one of the newest learning theory for the 'digital age' thus connectivism. The author views these theories from [22] perspective who examined them using the community of inquiry (COI) model. The COI model from [26] focuses on social, cognitive, and teaching presences. The application of these theories in TEL particularly in DL environment is discussed.

Behaviorist Perspective

Behaviorism theory asserts that learning manifests itself in changes in behaviors that are acquired as a result of an individual's response to stimuli. The major behaviorist theorist include Edward Watson, John Thorndike and B.F Skinner. Behaviorist models of DL pedagogy stress the importance of using an instructional systems design model where the learning objectives are clearly identified and stated, apart from the learner and the context of study [22]. Key principles used when designing instruction materials in these models include the production of observable and measurable outcomes in students to be used for assessment [25].Cognitive presence is created through structured processes in which learners' interest is stimulated, informed by both general and specific cases of overriding principles and then tested and reinforced for the acquisition of this knowledge [22]. It has significant reductions in social presence. Almost all of teaching approaches supported by behavioral theories fall under the general category of "direct" or "teacher-centered" instruction. They use instructional approaches like tutorials, explicit teaching, and programmed instruction. Computer-assisted instruction (CAI) and mastery learning are some examples of behaviorism as used in DL.

Cognitivist Perspective

The cognitivist view learning as a mental process which includes insight, information processing, memory and perception. In the cognitive paradigm, learning is active and students explore various possible response patterns and choose between them. Cognitivists focus on how information is received, organized, stored, and retrieved by the mind. They are of the view that applications require the learner to see relationships among problems and students must direct their own learning [27, 25]. They focus more on complex cognitive processes and internal mental processes such as information acquisition, processing, storage, and memory, which are vital to learning. According to [22], cognitive presence is created through designing learning materials in ways that maximize brain efficiency and effectiveness by attending to the types, ordering and nature of learning stimulations. Key factors when designing instruction processes include involving the learner in the learning process, organizing and sequencing information to facilitate optimal processing, and creating learning environments that allow and encourage students to make connections with previously learned material [22].

Both cognitivists and behaviorists are of the view that knowledge can be analyzed, decomposed, and simplified into basic building blocks so that irrelevant information is eliminated. However, behaviorists focus is on a well-designed environment while cognitivists emphasize efficient processing strategies [25].

Constructivist Perspective

Constructivist view learning as an active and social process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge or experience. They emphasize the importance of knowledge having individual meaning [22]. Aspects of constructivism can be found in self-directed learning, transformational learning, and experiential learning. The model supports learner-centered, interactive and active learning. They are of the view that learning is accomplished best using a hands-on approach. Intuitive thinking is encouraged and learners work primarily in groups. There is a great focus and emphasis on social and communication skills, as well as collaboration and exchange of ideas.

Specific approaches to education that are based on constructivism include critical exploration, inquiry-based learning, problem-based learning, cognitive apprenticeships and cooperative learning among others. Some activities encouraged in constructivist classrooms are experimentation, research projects, field trips, films and class discussions. Constructivist approaches can also be used in online learning. For example, tools such as discussion forums, wikis and blogs can enable learners to actively construct knowledge. A considerable amount of self-reflection occurs. Evaluation is an on-going process that is part of the learning process rather than coming only at the end of the course [25].When developing a DL program according to constructivists, designers must create stimulating environments that capture learners and enable them to formulate knowledge and derive meaning for themselves. These environments allow for collaboration and encourage meaningful dialogues so that understanding can be individually constructed [25].

Cognitive presence is located in as authentic a context as possible [22]. Much of which takes place in real-world contexts outside of formal classrooms. This resonates with a context-aware learning environment. Cognitive presence in these models also exploits the human capacity for role modeling, imitation and dialogic inquiry. It also assumes that learners are actively engaged and interact with peers. Social interaction is a defining feature of constructivist pedagogies [22, 25]. Therefore social presence is rich on constructivist models. Teaching presence in constructivist pedagogical models focuses on guiding and evaluating authentic tasks performed in realistic contexts [22]. Thus teacher facilitates the process of learning in which students are encouraged to be responsible and autonomous.

Connectivism Perspective

Connectivism is a recent theory of Networked learning which focuses on learning as making connections. It has been viewed by some studies like [25] as a DL theory. According to connectivists, learning is the process of building networks of information, contacts, and resources that are applied to real problems. Originating from Siemens and Downes, [28, 29], it was introduced as a theory of learning based on the assumption that knowledge exists in the world rather than in an individual's head. Connectivists argue that knowledge does not fit in a pre-packaged curriculum, although formalized education must deliver it to a degree. However, as learners become autonomous and seek information on their own, they come to understand the existence of an endless world of knowledge [25]. They also assume that much mental processing and problem solving can and should be off-loaded to machines, leading to Siemens' claim that learning may reside in non-human appliance [28, 25]. In contradiction to traditional theories, they are of the view that learning can result from social interaction, implying that learning can be envisaged as connectivity. This is because people derive skills and competencies from forming connections with outside sources while focusing on connecting specialized information sets [28, 25].

According to [22], connectivist cognitive presence begins with the assumption that learners have access to powerful networks and are literate and confident enough to exploit these networks in completing learning tasks. They further note that cognitive presence is enriched by peripheral and emergent interactions on networks, in which alumni, practicing professionals, and other teachers are able to observe, comment upon, and contribute to connectivist learning. In DL, interaction moves beyond individual consultations with faculty like in cognitive and behavioral pedagogy and beyond the group interactions and constraints of the learning management systems associated with constructivist pedagogy. Connectivist cognitive presence is enhanced by the focus on reflection and distribution of these reflections in blogs, twitter posts, and multimedia webcasts [22].

Connectivist pedagogy stresses the development of social presence and social capital through the creation and sustenance of networks of current and past learners and of those with knowledge relevant to the learning goals [22]. As [22] further explain, unlike group learning, in which social presence is often created by expectation and marking for participation in activities confined to institutional time frames, social presence on networks tends to be busy as topics rise and fall in interest.

Teaching presence is created by the building of learning paths and by design and support of interactions, such that learners make connections with existing and new knowledge resources. They view a teacher as a role model and fellow node in a network while learning should involve practice and reflection. Unlike earlier pedagogies, the teacher is not solely responsible for defining, generating, or assigning content, rather, learners and teacher collaborate to create the content of study, and in the process re-create that content for future use by others [22].

However, as [22] note, in connectivist space, structure is unevenly distributed and often emergent, seldom leading to a structure that is optimally efficient for achieving learning goals. It also fits poorly with a context in which students are taking more formal and traditional courses that use a constructivist and or a cognitive-behaviorist model.

Instructional Framework

Sound educational practice whether on campus or in a DL environment requires clear understanding and proper use of an instructional framework. The instructional framework discussed in this section is proposed by [30]. It is a standard instructional framework. This particular framework is heavily influenced by learning theories. It comprises of interrelated approaches which must be properly integrated for effective teaching and learning to occur. The levels of approaches range from a broad approach, to a specific teaching behavior or technique. They include: instructional models, strategies, methods and skills (Figure 2.1).

Instructional models represent the broadest level of instructional practices and present a philosophical orientation to instruction. Models are used to select and to structure instructional strategies, methods, skills, and student activities for a particular instructional emphasis. They are related to learning theories. *Instructional strategies* determine the approach a teacher or instructor may take to achieve learning objectives. Within each model several strategies can be used. *Instructional methods* on the other hand are used by teachers to create learning environments and to specify the nature of the activity in which the teacher and learner will be involved in during the lesson. While particular methods are often associated with certain strategies, some methods may be found within a variety of strategies as illustrated in Figure 2.2. A right instructional method for a particular lesson depends on many things, among them are the age and developmental level of the students; what the students already know; what they need to know to succeed with the lesson; the subject-matter content; the objective of the lesson; the available people, time, space and material resources, and the physical setting [31]. This should apply in both traditional class environment and in a DL environment. *Instructional skills* are the most specific instructional behaviors. These are used constantly as part of the total process of instruction. They are necessary for procedural purposes and for structuring appropriate learning experiences for students. A variety of instructional skills and processes exist. Some factors which may influence their selection and application include student characteristics, curriculum requirements, and instructional methods. Instructional skills include such techniques as questioning, discussing, direction-giving, explaining, and demonstrating. They also include such actions as planning, structuring, focusing, and managing.

Figure 2.1 below adopted from [30] with little modification summarizes the instructional framework. It shows the relationship between the instruction models, strategies, methods and skills.

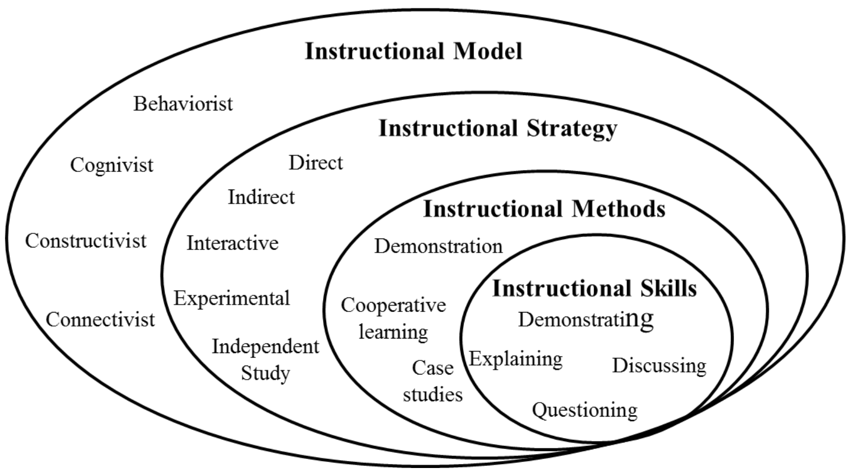

Figure 2.1: The instructional framework (adopted from [30])

Instructional Strategies and Methods

Although instructional strategies can be categorized, the distinctions are not always clear-cut. Sometimes they overlap each other as stated by [32]. The fundamental strategies and their instructional methods as presented in [30] and [32] are discussed below. They include direct, indirect, interactive, experiential and independent instruction strategies.

Direct instruction strategy is highly teacher-centered and is among the most commonly used. The strategy is effective for providing information or developing step-by-step skills. It also works well for introducing other teaching methods. Some of the advantages of this strategy include having very specific learning targets and being relatively easy to measure student gains. It is good for teaching specific facts and basic skills. Furthermore, it helps to clarify lesson objective. The disadvantages of this model among others include the possibility to repress teacher creativity. It requires well-organized content preparation and good oral communication skills. Steps must be followed in prescribed order. It may not be effective for higher-order thinking skills depending on the knowledge base and skill of the teacher. Possible teaching methods in this strategy include structured overview, lecture, explicit teaching, drill and practice, demonstrations among others.

Indirect instruction strategy is mainly learner-centered. This strategy seeks a high level of learner involvement in observing, investigating, drawing inferences from data or forming hypotheses. In order for learners to achieve optimum benefits during indirect instruction, it may be necessary for the teacher to pre-teach the skills and processes necessary to achieve the intended learning outcomes. According to [32], it is most appropriate when thinking outcomes are desired; attitudes, values, or interpersonal outcomes are desired; process is as important as product; students need to investigate or discover something in order to benefit from later instruction; there is more than one appropriate answer; the focus is personalized understanding and long term retention of concepts or generalizations; ego involvement and intrinsic motivation are desirable; decisions need to be made or problems need to be solved; and, life-long learning capability is desired. This strategy is influenced by constructivism to some large extend. But also behaviorism and connectivism to some small extend tend to use this strategy too. The advantages of this strategy include flexibility in that it frees students to explore diverse possibilities and reduces the fear associated with the possibility of giving incorrect answers. It also fosters creativity and the development of interpersonal skills and abilities. Students often achieve a better understanding of the material and ideas under study and develop the ability to draw on these understandings. Its drawbacks include more time consuming than direct instruction. Teachers relinquish some control, and outcomes can be unpredictable and less safe. It is not the best way of providing detailed information or encouraging step-by-step skill acquisition. It is also inappropriate when content memorization and immediate recall is desired. Skills and processes when this strategy is in use include observing, encoding, recalling, classifying, inferring, interpreting data, predicting, elaborating, summarizing among others. The possible teaching methods used in this strategy include problem solving, case studies, reading for meaning, guided inquiry, reflective discussions, writing to inform, concept formation, concept mapping, concept attainment among others.

Interactive instruction strategy relies heavily on discussion and sharing among participants. Students can learn from peers and teachers to develop social skills and abilities, to organize their thoughts, and to develop rational arguments. The strengths of this strategy include fostering mutual responsibility and students learn to be patient, less critical and more compassionate. However some of the limitations include some students do not work well this way, students who prefer working independently find it hard to share answers. Aggressive students try to take over and bright students tend to act superior. Social constructivists support this strategy. Connectivists who support networked learning and also view learning as a social interaction use this strategy to. Possible teaching methods in this strategy include debates, role playing, panels, brainstorming, peer partner learning, discussion, laboratory groups, projects, tutorial groups among others.

Experiential learning is inductive, learner-centered, and activity oriented [32]. The emphasis in experiential learning as [32] explains is on the process of learning and not on the product. Experiential learning is an effective instructional strategy if direct or hands-on experience is needed. It can be viewed as a cycle consisting of four phases according to Kolb's experiential learning cycle model [33, 34]. They include: experience (an activity occurs), reflective observation, abstract conceptualization (analyzing and inferring) and active experimentation (applying or doing). (Kolb's model is revisited in *section 3.2.2*). The strength of experiential learning is that it greatly increases understanding and retention. Students are usually more motivated when they actively participate and teach one another by describing what they are doing. Some of the limitations of this strategy may be the limitations on financial resources, and lack of available time. Possible teaching methods of this strategy include field trips, narratives, conducting experiments, simulations, games, storytelling, role-playing, model building and surveys.

Independent study refers to the range of instructional methods which are purposefully provided to foster the development of individual student initiative, self-reliance, and self-improvement. Independent study encourages students to take responsibility for planning and pacing their own learning. The advantages of this method include high retention power of the learning skills developed. Students can learn to increase the rate at which they understand new material. There is a greater opportunity for transfer of learning to other subjects. There is also increased opportunities for students to problem solve what is needed to learn and students may learn how to pace learning and thereby gain self-confidence. Some of limitations of this strategy include distractions that may possibility occur thus it requires self-discipline. In addition, appropriate materials may not be available or accessible. Possible teaching methods in this strategy include essays, computer assisted instruction, journals, reports, learning activity packages, correspondence lessons, homework, research projects and assigned questions.

Figure 2.2 adopted from [32] sums up the instructional strategies and their related teaching methods.

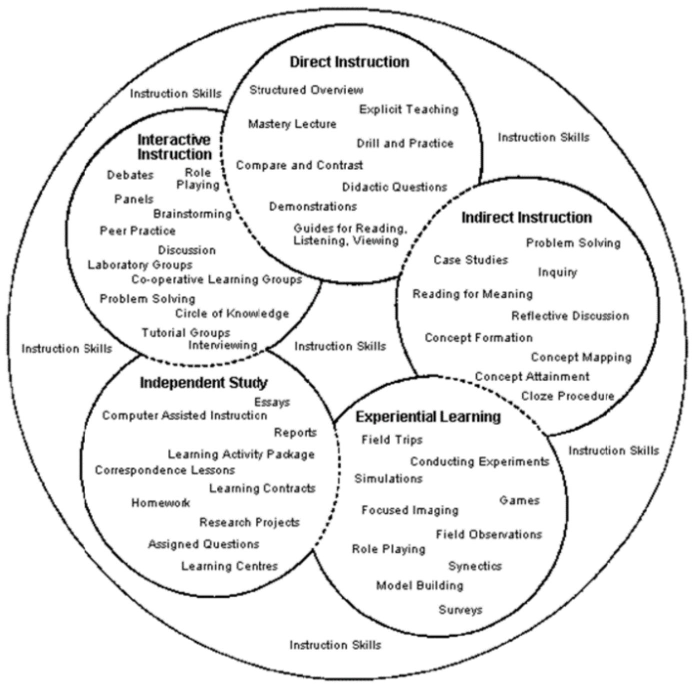

Figure 2.2: Instructional strategies and methods (Adopted from [32])

2.1.2 TEL and Distance Learning

DL is one form of TEL educational set up that has greatly evolved under the significant advancements in technology. There exist different definitions of DL but what cuts across these definitions is the fact that the learners and teachers are separated by time and distance or both, in that a traditional educational setting such as classroom is not necessary [20, 25]. Therefore the teaching and learning process relies on technology.

Different studies have noted that DL offers attractive options for teaching and learning. The many benefits include flexibility, accessibility, enhanced communication and interaction, and a variety of teaching and learning modes. DL is particularly useful for students that cannot attend courses on campus due to overly busy schedules. Thus, it gives an attractive learning opportunity for learners who are restricted by time and space. It can also improve the self-directed learning ability of learners. In that, successfully completing DL courses builds self-knowledge and encourages learners to take responsibility for their learning. Furthermore, DL remains as a viable option to address and match growing demand for higher education. More so in Africa where there is a growing demand to build skills for the knowledge economy, yet 93% of the college-aged population as noted by [35] is not in college due to the high cost and limited access. In addition to this, a phenomenon that is generating heated debates and shaking the education world right now and cannot go without mentioning when talking about DL is massive open online course (MOOC). MOOCs, as currently designed, address two major challenges facing postsecondary education: access and cost [36]. They hold promise to increased access to higher education.

The Evolution of DL

Given the requirement of DL to be technologically mediated, it is common to think of its development or its evolution based on the predominate technologies employed for its delivery. According to [8] view of transformations in DL, Computer Based Education (CBE) was one of the initial stages, leading to online education and electronic learning (e-learning). The emergence of e-learning provided an advanced form of DL commonly referred to as online learning by incorporating the use of information technologies to the learning process hence offering higher education the opportunity to expand the borders of classrooms through DL.

Mobile learning (m-learning) is another stage in the progress of e-learning. It is not only wireless or Internet based e-learning but also should include the anytime anywhere concept without permanent connection to physical networks [5]. According to [11], m-learning refers to the use of wireless devices for the purpose of learning while on the move. Sharples and colleagues' [37] view of m-learning embraces both learning with portable technology, and also learning in an era characterized by mobility of people and knowledge where the technology may be embedded in fixed objects. The frequently cited affordances of m-learning as noted in [11] include portability, social interactivity, context, and individuality. Specifically, *portability* is the most distinctive feature which distinguishes handheld devices from other emerging technologies. This factor makes other technological attributes such as individuality and interactivity possible. Now with the increasing use of mobile and wireless technology, context-aware technologies like pervasive and ubiquitous technologies (PUC) are gaining much popularity. The influence of these technologies in learning is now irrefutable. PUC and context-awareness is explained in *Section 2.2*

The High Drop-out Challenge in DL

However, as DL continues to evolve amidst technological advancements, learner retention in DL programs still poses a challenge as revealed in several studies [38, 39, 40]. Some consider the higher dropout rate in DL as a failure while others advise careful interpretation of the issue because of unique characteristics and situations that online learners have [41].

Several studies, theories and theoretical framework have been proposed to explain why learners drop out in DL courses. Lee and Choi in [42] classified factors that influence learners' decisions to dropout into three main categories; student factors (for example academic background, relevant experiences or skills and psychological attributes), course or program factors (for example course design, institutional supports and interactions), and environmental factors (for example work commitments and supportive environment). In [39] it was noted that age, delivery format and academic background have effects on dropout. According to [38], the variables that have been most frequently argued to have a causal effect on retention rate for online learners can be parsed into three categories: personal variables (e.g. age, gender, student's learning style among others), institutional variable (instructional effectiveness and faculty engagement) and circumstantial variables (academic interactions, student's life, work and family).

A study by [43] found out that internal factors (self-efficacy, self-determination, autonomy and time management), external factors (family, organizational, and technical support) and course factors (course relevance and course) were found to significantly impact learners' decisions to persist or drop out. The theoretical framework for adult dropout in online learning by [41] which is based on Rovai's model, sights individual characteristics (e.g. age, gender, academic background, employment status), external factors (family and organizational support) and internal factors (social integration, academic integration, technical usability issues and motivation) as the main factors that cause students to dropout or persistence.

Social integration has also been found to be an important determinant for persistence [18, 19]. Research as noted by [18] has shown a link between perceived social presence and perceived learning and satisfaction which are the main contributors to persistence in online courses. Social presence as described by [44] is the ability of learners to project themselves socially and emotionally as well as their ability to perceive other learners as “real people”. It is the basis of collaborative learning [18].

Based on these studies [41, 42, 43, 38], factors that seem to cut across them and therefore at the center of focus in influencing the learners’ decision to drop out or persist include issues that involve: (a) the learner, (b) the technology (c) the physical environment and (d) the learning environment. Issues focusing on the learner may refer to individual attributes like age, learning style or preference, academic background among others. Issues on technology may include the device usability and network or communication infrastructure. Physical environmental may include issues originating from the learners surrounding that may influence the learner’s learning process e.g. family or work commitments, location among others. Issues involving the learning environment may include the instructional strategy, course relevance, social integration or support for interaction among others.

Interaction among Components Contributing to Attrition

Notably, there is a strong interaction between these factors as noted by [41]. A few examples are highlighted below to demonstrate these interactions:

Physical Environment vs. Leaner vs. the Learning Environment

As [37] points out, learning is interwoven with other activities as part of everyday life. It cannot easily be separated from other everyday activities such as conversation, reading, or watching television, and these activities can be resources and contexts for learning. It is integrated with non-learning tasks as well organized into projects that are interleaved with everyday activities. Learning needs emerge when a person strives to overcome a problem or breakdown in everyday activity. There is anecdotal evidence to suggest that poor retention rates are frequently due to students’ difficulty in striking a balance between family and work demands and demands of their coursework as well as the extent to which students feel engaged, or integrated, into the academic setting [38]. Most adult learners (who constitute a great percentage of DL learners) have many responsibilities for their family as well as for their job, and these are two key factors affecting adult learners’ decision to drop out of online courses. When learners as explained by [41] have a heavy workload and little time for study, they are more likely to drop out of a course when they cannot get feedback or if it is hard to contact the instructors than when they can easily communicate with them and get more responses. If proper course design and technology are being used, some external problems are likely to be mitigated.

Learner vs. Learning Environment

Individual learner's attributes like the learning style complement with course factors like the instruction method as cited by [45]. As [45] further explains, different learners have different learning styles that require different teaching styles. When a teaching style is matched to a corresponding learning style of a particular student, that student benefits enormously and as a learner benefits, he or she is motivated to persist. Motivation is one of the most frequently studied variables in relation to dropout and satisfaction and relevance are the sub-dimensions of motivation [41]. According to [46] student satisfaction is a key indicator in students' decision to drop out of online courses. In their study, dropout students reported to have significantly lower satisfaction with Online learning than those who successfully completed (persistent students). Satisfaction and the relevance are known to be highly correlated with various course-related issues such as instructional design, organization courses, instructors' facilitation, and interaction [46]. This notion of matching teaching and learning styles is consistent with the learner centered approach. On the other hand, as mentioned earlier, research as noted by [18] has also shown a link between perceived social presence and perceived learning and satisfaction.

Technology vs. Learning Environment

Since DL is technologically mediated, technology usability issues and support play a very important role in determining the instructional strategy used hence influencing the mode of delivery. For example, communication infrastructure which has a great influence on internet speed, or constraints caused by the use of some technologies such as the limited screen size has a great influence on the mode of delivery that can be supported. Due to these limitations, these devices may not be able to directly accommodate or support certain learning process.

Furthermore, technology is evolving and changing rapidly in different aspect as well as transforming the learning environment. There is a continual co-evolution of technology and human learning. Individuals, groups and societies simultaneously are developing new modes of interacting with technology in parallel with adopting new patterns of learning [37]. With the increasing use of mobile and wireless technology, learning is moving outside the classroom into the learner's environment hence becoming more situated, personal and learner centered. Sharples and colleagues in [37] capture this convergence between learning and technology as follows - "Just as learning is being re-conceived as a personalized and learner-centered activity, so too are new digital technologies offering personalized services such as digital calendars. Just as learning is now regarded as a situated and collaborative activity, occurring wherever people, individually or collectively, have problems to solve or knowledge to share, so mobile networked technology enables people to communicate regardless of their location".

Physical Environment vs. Technology vs. Learning Environment
In additional, with further emergence of context-aware technologies, technology can now seamlessly integrate into the physical world due to their context-aware capabilities. This is changing how people learn. As technologies are getting smarter using various environmental awareness technologies, so too are the learning environment. For instance, instead of the learner and device being at a fixed and predetermined location, a mobile and context-aware learning fosters free movement. While the learner is moving with the device, the system can dynamically support learning by communicating with the embedded devices in the environment.

Furthermore, sometimes DL learners more so adult learners frequently get into unplanned situations like waiting in a doctor's waiting room or lounges, traveling etc. However, they may have time they could use for learning if only they had learning material or learning activities at hand or had access to their learning group. These situations may not be predictable, but in most cases these persons carry a mobile device with them which they may like to use for their studies as [47] points out. Therefore learning independently from time and location, thus being provided with unprecedented possibilities to learn on the move is of fundamental importance to these learners. Furthermore a learning environment that allows learning that can take place anywhere, anytime and on any device or infrastructure while enabling learners to exploit the resources or services in their neighborhoods could lead to learner satisfaction.

Learning Environment as a Focal Point
Looking at how these components interact, the components learner, technology and physical environment, in one way or the other have an influence or are influenced by the learning environment. They all tend to converge or meet at one central point which is the learning environment as illustrated in Figure 2. 3 below.

Therefore it can as well as be concluded that the learning environment is a focal point in influencing learner's decision to persist or drop out of DL programs. Thus learning environment plays a central role in motivating learners to persist in a DL program. Hence it should be the point of focus in order to achieve any effective learning that can lead to leaner motivation to persist in a DL program. However, as new trends in technology emerge, there have also been concerns on how to achieve effective learning environment when using these technologies in DL.

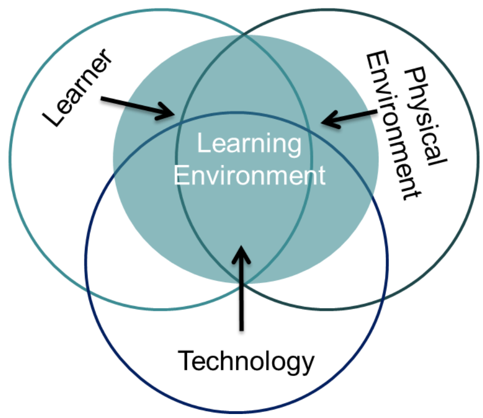

Figure 2.3: Learning environment as focal point in influencing learner's decision to drop out of DL programs

DL Theories and Frameworks Reviewed

Attaining an effective and all-inclusive learning environment in DL poses a great challenge. This is partly because of the evolving nature of DL due to technological changes. DL has been described as a changing paradigm, one that is perpetually evolving, non-static, and dynamic [48]. It has evolved through many technologies, theories and pedagogies. Nevertheless, distance education is still struggling to agree upon the theories it will use to build a framework [25]. No single theory has provided all the answers, and each has built on foundations provided by its predecessors rather than replacing the earlier prototype [22]. Simonson and colleagues in [49] are of the view that in an environment in which technology, society, economics, politics, and approaches to learning are all in transition suggests that theories, definitions, and the practice of DL will continue to be contested [49].

Though no single theory has provided all answers, however, as DL evolve alongside technological changes, there exist theories and frameworks that have been developed over the years to offer guidance in achieving effective learning environment in DL. Apart from the dominant learning theories of the past centuries thus Behaviorism, Cognitivism, Constructivism, and the new Connectivism theory, that have been applied to cater for the unique aspects of DL, DL theories have also been proposed beginning with classical theories that describe traditional DL. They include theories that emphasize independence and autonomy of the learner, industrialization of teaching, and interaction and communication [49]. However, as [28] points out, the natural attempt of theorists is to continue to revise and evolve theories as conditions change. At some point, however, the underlying conditions have altered so significantly, that further modification is no longer sensible, an entirely new approach is needed. Therefore as technology continues to evolve, some of these classical theories (i.e. theory of independent study, industrialization of teaching, equivalency theory) have been modified and also some new theories emerged as [50]notes. In this section, *Activity theory* and *Transactional Distance theory* which are the most current DL theories are discussed.

Activity Theory

Cultural-historical Activity theory originally by Vygotsky [51] focuses on understanding the human activity and work practices. It incorporates the notions of intentionality, mediation, history, collaboration and development [52]. According to [53], Activity theory is an analytic framework for understanding an individual's (subject) actions on learning material (object) mediated through artifacts, interacting with community, moderated by a set of rules, and distributed by a division of labor (Figure 2.4). As [52] explains, an activity is conceived as a unit of analysis. It consists of a subject and an object, mediated by a tool. A subject can be an individual or a group engaged in an activity. An activity is undertaken by a subject using tools to achieve an object (objective), thus transforming it into an outcome [54]. Tools can be physical such as a hammer or psychological such as language, culture or ways of thinking. Computers are considered as special kinds of tools thus mediating tools.

Activity theory also includes collective activity, community, rules and division of labor that denote the situated social context within which collective activities are carried out [52]. Community is made up of one or more people sharing the same object with the subject. Rules regulate actions and interactions with an activity. Division of labor informs how tasks are divided horizontally between community members. It also refers to any vertical division of power and status [52]. Just as artefacts or tools mediate the relationship between subject and object, rules mediate the relationship between subject and community. Similarly, division of labor mediates between community and object [52]. The key point of the Activity theory is the concept of mediation: human activity is always mediated from the artifact and never direct in its relationship with reality [56]. The activity system is illustrated in Figure 2.4 as presented in [55].

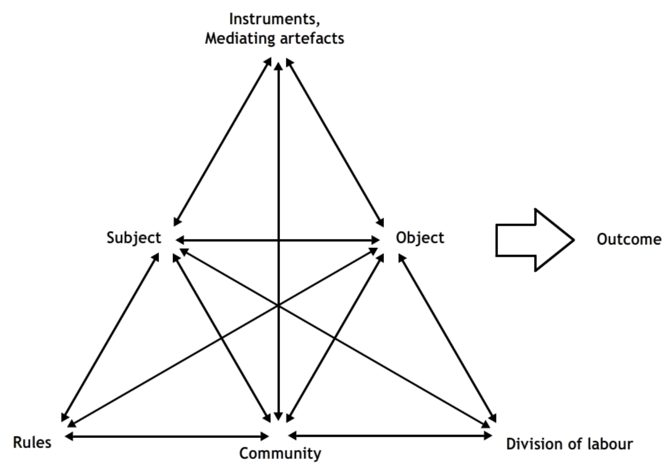

Figure 2.4: An activity network (adopted from [55])

Activity Theory in M-learning

A number of researchers like [37], [52] among others have utilized Activity theory as a theoretical framework for m-learning.

Investigating the dialectical relationship between learning and technology**,** [37] adapted Engeström's [57] expansive version of activity model and Pask's [58]Conversational theory. In their investigation, they focused on the communicative interaction between the learner and technology to advance knowing. They argued that, in order to understand the complexity of learning, there is need to analyze a distributed system in which people and technology interact to create and share meaning. But putting people on a par with computers and phones fails to take account of the unique learning needs and moral worth of each individual person. Therefore, they attempted to address this paradox by describing the activity system of mobile learning in a way that problematizes the dialectical relationship between people and technology. Following Engeström model, they analyzed learning as a cultural-historical activity system, mediated by tools that both constrain and support the learners in their goals of transforming their knowledge and skills. However, to explain the role of technology in learning, they separated two perspectives of tool-mediated activity. The semiotic layer describes learning as a semiotic system in which the learner's object-oriented actions (i.e. actions to promote an objective) are mediated by cultural tools and signs. The technological layer shows learning as an engagement with technology. These layers as can be prized apart, to provide either a semiotic framework to promote discussion with educational theorists to analyze the activity and discourse of mobile learning, or a technological framework for software developers and engineers to propose requirements for the design and evaluation of new mobile learning systems. The layers can also be superimposed to examine the holistic system of learning as interaction between people and technology. Here, the semiotic fuses into the technological to form a broader category of technology than physical artefacts. Therefore, in their framework, they set up a continual dynamic in which the technological and the semiotic can be moved together and apart, creating an engine that drives forward the analysis of mobile learning. However in their model, they rename Engeström's cultural factors with terms – Control, Context and Communication.

The study Activity theory for designing mobile learning by [52] bases its argument on Engeström [59] view that learning is fundamentally situated and socially mediated and Vygotsky [51] view that depicts learning as an interaction with more capable peers, helping the learner through the zone of proximal development (ZPD) - (ZPD is the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers). In the study, [52] argued that it is through the interaction with other learners and the teacher, mediated by mobile technologies, that the ZPD emerges. Learning is not a neat transfer of information, but a complex and often messy network of tool-mediated human relationships that must be explored in terms of social and cultural practices that people bring to the uses of tools they share. This situated and social nature of learning from Activity theory means that we need to be concerned with the context of use. Individuals rarely perform activity on their own. The author backed this argument with [59] view that human activities always exist in a social context, in that individuals involved in a particular activity are simultaneously members of other activity groups that have different objects, tools and social relations. The author further notes that mobile technology is not perceived as the object of learning but as a tool to support students' learning activities [52].

Therefore, according to [52], Activity theory provides a powerful vehicle for developing m-learning since it provides an ideal theoretical framework for describing the structure, development and human work and praxis, that is, an activity in context. The author also noted that Activity theory can help designers to better understand the social and material relations that affect complex human learning and learners' interaction with others as mediated by tools. This is because Activity theory provides a philosophical framework for understanding collective human work activities as embedded within a social practice (e.g. an institution) and mediated by artifacts, such as mobile technologies. According to [52] , two basic ideas are central to Activity theory. First, the human mind emerges, exists and can only be understood within the context of human interaction with the world. Secondly, this interaction, that is, activity, is socially and culturally determined. Therefore, Activity theory can be used as a lens to analyze learning processes and outcomes for the design of mobile learning [52]. Secondly, it is powerful framework for designing constructivist & student-centered learning environments and thirdly, it provides the design of context-aware applications that are crucial for mobile technologies [52].

Though certain limitations and unsolved problems in Activity theory have been raised for example being criticized for being difficult to test empirically because society is too multifaceted and complex, as noted in [11], still some researchers recognize it as a powerful framework for designing constructivist learning environments and student-centered learning environments.

Transactional Distance Theory

Theory of Transactional Distance (TD) is one of the core theories in the field of DL and the theoretical discussion about it is valuable. It defines the critical concepts of DL as noted by [11]. The theory was originally part of a theory of independent learning developed in 1972. Transactional Distance, refers to the theory of cognitive space between instructors and learners in a DL educational setting, formulated by Michael Moore. It presents a definition of DL which implies the separation of teachers and learners [60, 11]. Moore explains that when referring to DL, there is more than a geographic separation of learners and teachers. There is also a distance associated with understanding and perception also partially caused by geographic distance. Therefore, Moore defines transactional distance as the psychological and communication space between the learner and the teacher, thus the interplay of teachers and learners in environments that have the special characteristics of their being spatially separate from one another [60].

The transaction that referred to as DL occurs between teachers and learners in an environment of separation of teachers from learners. It is a distance of understandings and perceptions that might lead to a communication gap or a psychological space of potential misunderstandings between people. A large transactional distance such as that between geographically separated learners and instructors in an asynchronous, online learning environment may contribute to students' feelings of isolation. They may feel disconnected which can lead to reduced levels of motivation and engagement. This may result to attrition. Therefore, as argued by Moore, if learning outcomes in any distance education course are to be maximized, transactional distance needs to be minimized or shortened.

The degree of transactional distance depends on three variables: dialogue, structure, and learner autonomy. *Dialogue* is the interaction between learners and teachers. The important factor involved is communication [25]. However, according to [50], dialogue, in this case, is something more than mere communication and interaction between learner and teacher. In particular, this type of communication occurs within the context of clearly defined education targets, cooperation and understanding on the part of the teacher and, ultimately, culminates in solving the learner's problems [50]. According to [50], Moore perceives dialogue as an element connected with the quality of communication rather than the frequency. Therefore, the objective is the quality and nature of the dialogue and not its frequency. The second variable, *structure* according to Moore's approach, is the extent to which a course's elements (learning objectives, content themes, presentation strategies and evaluation activities) change to meet the specific needs of the individual learner [25]. According to [50], Moore also perceives structure as a qualitative feature rather than quantitative. The third variable thus the *Learner autonomy* is defined by Moore as the extent to which the learner exerts control over learning procedures or learning activities and processes [25, 50] or the degree of self-directedness of the learner. Autonomy, in other words, is the degree of decision the learner has over issues such as educational goals, manner of teaching followed, and rate of progress and methods of assessment [50]. According to [25], the teaching and learning process is a shared responsibility that occurs through a dialogue between a teacher and a student. Therefore the learner must be aware of the learning activity and think about what is being learned (meta-cognition). The learner must also utilize critical thinking skills to develop a true awareness of the learning process. This will come about with the use of reflective practices, which can be created through dialogues with the instructor and with other students.

The most appealing component of Moore's transactional distance theory is the inverse relationship between structure and dialogue [11]. Moore assumes that transactional distance and dialogue are in inversely proportion to each other, meaning that any increase in either leads to decrease of the other. Moore also assumes that increase in course structure leads to reduction of dialogue and, consequently, increase in transactional distance [50] as illustrated in figure 2.5(a). That is, as structure increases, transactional distance increases. However, as dialogue increases, transactional distance decreases [11]. This hypothesis has been verified in several studies [11].

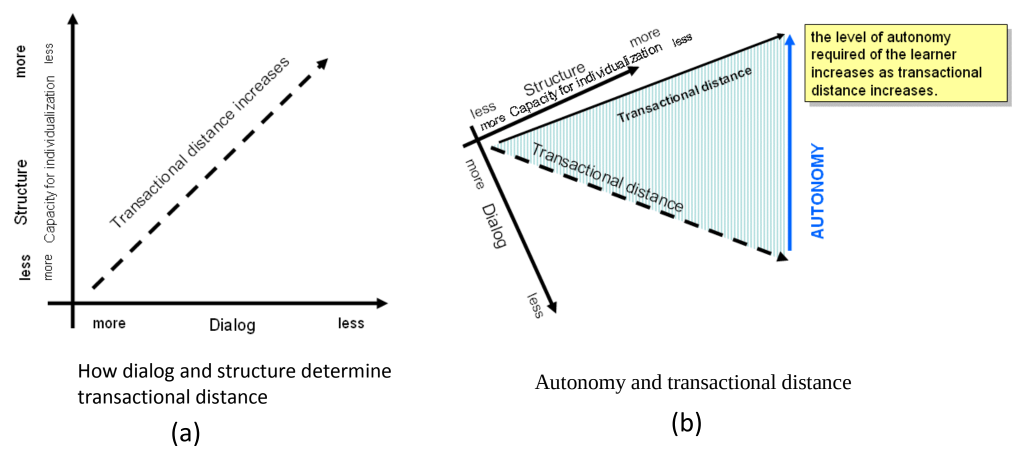

Figure 2.5: Relationship between variables in transactional distance theory as illustrated by Bornt in [61]

However, as [50] further points out, limitations are imposed on the reverse direction; reduction in *structure* does not result in increase in *dialogue* and, consequently, reduction of *transactional distance* throughout the whole spectrum. Moore also assumes that *transactional distance* and *autonomy* are proportional to each other [50], as transactional distance increases, so does learner autonomy as illustrated in (Figure 2.5 (b)).

Since its first appearance in publications, this theory has influenced numerous researchers and practices. Many scholars praise it as a classical and all-encompassing theory of DL and view it as a major contribution to the field of DL. As [11] notes, studies about transactional distance theory commonly indicate its usefulness in understanding DL and evaluate its usefulness as a pedagogical and philosophical framework. It also encompasses both organizational and transactional issues without losing sight of the learner and the institution altogether [25]. The influence of communication media on transactional distance is another interesting aspect of this theory as noted by [11].

However, several issues raised from previous studies [60, 50, 11, 8] include the problems with terminology, the divergent views about relations between variables and an inability to explain the individual's social characteristics hence unable to capture the social aspects of learning and newer forms of social technologies. Several researchers have addressed the need for a more refined theory that addresses these issues. They have tried to revise, modify or approach the theory in different ways. For example [8] approach modifies transaction distance theory by incorporating it into the epistemological framework of realism. While [11] whose approach the current study borrows heavily from, uses several elements of activity theory to modify transactional distance theory.

Park's Pedagogical Framework - Reconsidering Transactional Distance Theory

Park's pedagogical framework [11] adapted the original concepts of transactional distance theory including the definition but modified it by adding a new dimension to reflect the characteristics of mobile technologies that support both individual and social aspects of learning. Park [11] argued that due to the recent developments of emerging communication technologies, structures of learning are built not only by the instructor or instructional designer as depicted in transactional distance theory, but also by collective learners. Park further argued that dialogue is also formed not only between the instructor and learners, but also among the learners themselves. In the study, [11] further noted that structure and dialogue, previously defined as being under the instructor's control, have evolved into something that learners can also form. Therefore [11] adds a new dimension to transactional distance theory to address these aspects. This new dimension connotes *individual versus collective (or social)* activities where Park considers the importance of the social aspects of learning as well as newer forms of social technologies.

Therefore [11] uses several elements of activity theory to add this dimension and creating a pedagogical framework as follows. First by confining the unit of analysis to *activity*. Secondly, having individualized and socialized activities *mediated* by communication technology which is one kind of cultural-historical artifact in Activity theory. Both transactional distance theory and Activity theory consider mediation to be important [9]. Thus, with *mediation* at the center of the framework, individualized activity at one extreme indicates a form where a learner is isolated from communicating with other students, and socialized activity at the other extreme indicates a form where students work together, share their ideas, and construct knowledge. At the same time, activities are mediated by the rule which can be either highly structured with fewer dialogic negotiations (i.e. high transactional distance) or loosely structured with more free dialogic negotiations (i.e. low transactional distance). Thirdly, Activity theory Engeström's definition forms a part of the basis for transactional distance theory, which is a framework for understanding the relations of key variables (structure, dialogue, and autonomy) in the context of DL.

Park [11] further noted that a dimension indicating the range of individualized to socialize activity can be a useful lens for reviewing diverse mobile learning activities as illustrated in Figure 2.6. Therefore, by integrating some of the Activity theory elements into transaction distance theory, [11] generated a conceptual and pedagogical framework based on high versus low transactional distance and individualized versus socialized activity. As shown in Figure 2.6, the four types of m-learning generated include (1) high transactional distance socialized m-learning, (2) high transactional distance individualized m-learning, (3) low transactional distance socialized m-learning, and (4) low transactional distance individualized m-learning.

In *Type 1*, High Transactional Distance and Socialized Mobile Learning Activity, the learners have more psychological and communication space with their instructor or institutional support. The learners are involved in group learning or projects where they communicate, negotiate, and collaborate with each other. Learning materials or the rules of activity are delivered from the predetermined program through mobile devices. Transactions mainly occur among learners, and the instructor or teacher has minimal involvement in facilitating the group activity. It is noted that this type might replace the traditional technology-mediated classroom group activity where students in a group or pair conduct given tasks or assignments.

In *Type 2*, High Transactional Distance and Individualized Mobile Learning Activity, the individual learners have more psychological and communication space with the instructor or instructional support. The individual learners receive tightly structured and well organized content and resources (e.g., recorded lectures, readings). The individual learners receive the content and control their learning process in order to master it. The interactions mainly occur between the individual learner and the content. The type demonstrates an extension of e-learning which allows greater flexibility and portability. Individual learners fit this flexible learning into their mobile lifestyle. It is mostly influenced by the context regarding when and where to learn.

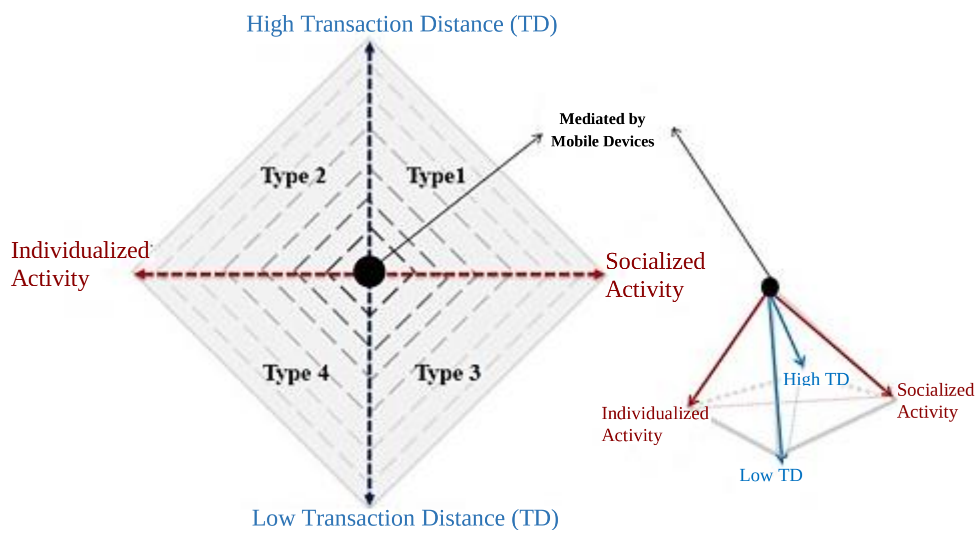

Figure 2.6: Park's Pedagogical Framework (adopted from [11])

In *Type 3,* Low Transactional Distance and Socialized Mobile Learning Activity, the individual learners interact both with the instructor and other learners. They have less psychological and communication space with the instructor and loosely structured instruction but work together in a group as they solve the given problem and try to achieve a common goal and engage in social interaction, negotiation, and frequent communication naturally. This type demonstrates the most advanced forms in terms of the versatility of mobile devices and learners' social interactions as pointed out by [11].

In *Type 4,* Low Transactional Distance and Individualized Mobile Learning Activity, there is less psychological and communication space between instructor and learner and loosely structured and undefined learning content. On this basis, individual learners can interact directly with the instructor, and the instructor leads and controls the learning in an effort to meet individual learners' needs while maintaining their independence. This type shows characteristics unique to support blended or hybrid learning.

2.1.3 Overview on Personalized Learning

Personalized learning has been defined with different accents by different authors. According to [62] personalized learning refers to learning that is tailored to the preferences and interests of various learners, as well as instruction that is paced to a student's unique needs. Personalized learning has also been used to refer to the tailoring of pedagogy, curriculum and learning environments by learners or for learners in order to meet their different learning needs and aspirations[1]. However what cuts across most definition is the fact that learning is tailored to learner needs and secondly the learner is involved in the process. Personalization does take into account the pace at which the learner is progressing. It also aims to explore the entire potential of the learner including the abilities, the sensibilities and competencies among other that characterizes each person. The intent is to reach a cognitive excellence, by developing all aptitudes, capabilities and talents. As a result academic goals, curriculum and content — as well as method and pace — can all conceivably vary in a personalized learning environment [62]. For teachers, personalized learning is about facilitation more than dissemination, while the learner, guided by the teacher, is an active co-designer of the learning pathway-experience. In that, the learner actively participate to the construction of his/her own curriculum. Dialogue is a central element to personalization. It also embraces learning that happens anywhere, anytime, anyplace. This 'anywhere, anytime, anyplace' learning can be seen in light of the forces of globalization that are influencing this latest trend in education, where time, space and place are experienced as compressed.

Adaptive Learning Vs Personalized Learning

The key to the success of accessing learning resources in using context-aware technologies like mobile devices as [63] argues is adaptation and personalization. Adaptation deals with taking learners' situation, educational needs and personal characteristics into consideration in generating appropriately designed learning experiences. Personalization on the other hand, as [62] explains, in addition to responding to students' needs and interests, it teaches them to manage their own learning i.e. they take control and

[1] https://en.wikipedia.org/wiki/Personalized_learning

ownership of it. It is not something that is done to them but something that they participate in doing for themselves as [62] further explains. It may also deal with the customization of the system features, including also issues which can be adapted and specified by learners themselves, such as the system interface, the preferred language, or other issues which make the system more personal [4]. Unlike individualized instruction and adaptive learning, personalized learning according to [62], involves the student in the creation of learning activities and relies more heavily on a student's personal interests and innate curiosity. Instead of education being something that happens *to* the learner, it is something that occurs as a result of what the student is doing, with the intent of creating engaged students who have truly learned how to learn as [62] explains. The key attributes that makes personalization stand above adaptive learning is learner involvement. However, since the most effective (and unrealistic) application of true personalized learning would require one-on-one tutoring for every student based on their interests, preferences, needs and pace, personalized learning is often conceived of as an instructional method that incorporates adaptive personalized learning, allowing students to make suggestions and control their own academic experiences [62].

Technology can be a powerful tool in facilitating personalized learning environments as it allows learners access to research and information. It provides a mechanism for communication, debate, and recording learning achievements that can be utilized in personalized learning. It can help achieve timely interventional responses which is crucial in personalized learning. Therefore, as [62] notes, technology when employed properly and meaningfully can help educators deliver personalized instruction. Some studies that have applied context-awareness technologies to attain adaptive and personalized learning are highlighted in the next section.

2.2 Context-awareness in Educational Setting

This section gives an overview on pervasive and ubiquitous computing (PUC), context and context-awareness. It also examines how context-awareness has been applied in educational setup within external context dimension and internal context dimension. The section revisits adaptation and personalization by looking at a couple of studies that have used these notions to address the learner diversity challenge.

2.2.1 Pervasive and Ubiquitous Computing

Context-awareness is proposed as an essential component of pervasive and ubiquitous computing. Since the study's focus is on context-awareness, in order to better explain it, an overview of pervasive and ubiquitous computing (PUC) is necessary.

PUC is the growing trend towards embedding microprocessors in everyday objects so that they can exchange information [64]. The words "*pervasive"* and "*ubiquitous"* simply means "*existing everywhere"* [64]. Mobile devices, embedded systems, wearable computers, sensors and actuators, RFID tags among others make the environment pervasive [65]. PUC relies on the convergence of wireless technologies, advanced electronics and the Internet. The devices are fully connected and constantly available hence enabling the integration of information and communication technologies (ICT) into people's lives and environments. In this environment, the world around us (e.g., key chains, coffee mugs, computers, appliances, cars, homes, offices, cities, and the human body) is interconnected as pervasive network of intelligent devices that cooperatively and autonomously collect, process and transport information, in order to adapt to the associated context and activity [8]. Thus, it enables authorized access to anytime-anywhere any device - any network - any data. The goal of pervasive computing is to create ambient intelligence where network devices embedded in the environment provide unobtrusive connectivity and services all the time, thus improving human experience and quality of life without explicit awareness of the underlying communications and computing technologies [64, 65, 8].

PUC is a rapidly developing area of ICT. Different researchers use a variety of terminology to refer to systems in this area; for example, *"ubiquitous computing" "pervasive computing"*, *"context-aware computing"* or *"augmentation of the real world"*. In this study the terms pervasive and ubiquitous computing (PUC), pervasive and ubiquitous are used interchangeably. However when referring to the application of these technologies in learning, the terms pervasive learning and context-aware learning are used.

The integration of PUC into learning has led to pervasive learning. Pervasive learning is learning that is available anywhere anytime. It is learning enhanced with intelligent environment and context-awareness [65]. This technology enables seamless combination of virtual environment and physical spaces or real-world so that we are being frequently surrounded by and immersed in learning experiences. Any setting in which students can become totally immersed in the learning process can be seen as pervasive learning environment [66]. Pervasive learning takes part in an experience of immersion as a mediator between the learner's mental (e.g., needs, preferences, prior knowledge), physical (e.g., objects, other learners close by) and virtual (e.g., content accessible with mobile devices, artifacts) contexts. Where these contexts overlap and form a single entity is addressed here as a pervasive learning environment [47]. It is characterized by providing intuitive ways for identifying right collaborators, right contents and right services in the right place at the right time based on learners surrounding context [66]. A pervasive learning environment utilizes context-aware applications to deliver the learning materials depending on the user context [65].

2.2.2 Context and Context-awareness

The pervasive computing research has strong focus on the seamlessness of technology, i.e., the technology should be integrated into people's life so that they do not even notice it [2]. As a response, the concept of context-awareness has emerged. Context in itself is an all-embracing term. However, a more general and widely accepted definition of context is by [3] who define context as any information that can be used to characterize the situation of an entity. An entity in this case is a person, place, or object that is considered relevant to the interaction between the user and application, including the user and applications, location, time, activities, and the preferences of each entity [3]. In the field of TEL, context has been defined as the current situation of a person related to a learning activity [4]. To provide adequate service for the users, applications and services should be aware of their contexts and automatically adapt to their changing contexts – known as context-awareness [3]. Therefore context-awareness simply means that one is able to use context information [5]. As stated in [4], a system is considered as context-aware if it can extract, interpret and use context information and adapt its behavior and functionalities to the current context of use. Prekop and colleagues in [6] refer to a context-aware application as one that uses the context of an entity to modify its behavior to best meet the context of the user. These systems perceive characteristics and situations of the entities relevant to the computing setting (e.g., people, devices etc.), i.e., context, to tailor themselves accordingly [2].

Context and context-awareness may provide a PUC environment with the ability to adapt the services or information it provides by implicitly deriving the user's needs from the context that surrounds the user at any point in time [6]. In that, instead of requesting the user to instruct the system to perform a task, the system carries out this task automatically and in a timely manner based on the current situation and conditions of the user and environment. Therefore, the system needs to have the capability to recognize and understand the situation and conditions. Such capabilities can be best described as *awareness* [5, 7]. It is the ability to implicitly sense and automatically derive the user's needs that separates context-aware applications from more traditionally designed applications [6]. The goal of context-aware system is to utilize contexts to ease a user's tasks and hence fulfill his/her needs [5]. According to [7] by enabling the acquisition and interpretation of context, context-aware system utilizes the available contexts to offer at least the following advance features: Learning and understanding of user and service behaviors; recording and presentation of the obtained contexts; intelligent adaptation through reasoning or prediction of available contexts of the user and his/her environment and further inference of implicit contexts based on the available contexts that are not directly measurable using sensors. These features remain active research areas in finding suitable techniques to apply them in the many application domains and environments.

The assimilation of PUC in learning has led to a major leap forward in TEL. These technologies have changed the traditional concept of learning so that we are being frequently surrounded by and immersed in learning experiences. More so, their context-awareness capabilities provide great potential to adapt the learning spaces to different contexts of use hence capable to cater for different learners needs. Some other potential benefits of these technologies, particularly in teaching and learning as cited by several studies like [4, 8, 67] among others include the capability to explore the potential of the new flexible and cost-effective mobile platforms; the potential to provide learners with personalized learning experiences in real world situations – thus, the integration of real and virtual learning environments and provision of an adequate environment with cognitive apprenticeships which include features like situated learning, scaffolding among other. They also have the potential to advance e-learning and m-learning a step further from learning at any time anywhere to be at the right time and right place with right learning resources and right learning peers. In addition, the offer the possibility to create a dynamic and integrated system for learning as well as provision of more adaptive and active learning supports. They have also been proposed to be the best solution to bridge the technological and pedagogical gap in m-learning. Therefore, it is worthy acknowledging that indeed context-aware capabilities of PUC promises tremendous potential to offer great innovations in the delivery of education.

Context is perceived as an open concept [2]. Since context is open, “Contextual factors" can refer to many things. Therefore, there may exist different types or ways of context classifications. Nevertheless, there are two commonly used classification of context as presented in several studies like [2, 6]. One of the classification approach categorizes context as *computing context* (e.g. network connectivity, device, bandwidth among others); *environmental context* (e.g., lighting, noise level, and weather among others); *user context* (e.g. user profile, preference, mood/behavior among others) and Physical context (e.g. Location, time and date among others). The other commonly used classification approach is by categorizing context as *external context* (e.g. location, light, sound pressure etc.) and *internal context* (e.g. user’s goals, preferences, tasks, emotions etc.).

2.2.3 Application of Context-awareness in TEL

The issue of context is quickly becoming an important topic of research related to TEL domain. Context in TEL systems is considered for personalization, adaptation and recommendation of suitable learning material to the user as noted in [12]. So far several studies have been carried out and a number of context-aware applications have been developed. A majority of these studies have had a focus on the external dimension of context in particular the physical context and computing context.

In TEL, the physical context has been used to denote the surrounding of learning activities such as objects, events, location among others that are peripheral to the learning activities but may have an impact on the learner’s behavior or influence the learning process. Though there are many aspects of physical context, however, location based context-aware environment has been the locus of most these of studies. According to [68], the provisioning of services using location information is known as location-based services (LBSs). There exist location-based experiences occurring in our daily lives such as location-based information services, location-based games, and location-based ubiquitous learning. Examples of applications built specifically for a *location of use* for learning purposes as cited in [69] include among others: TANGO which has been designed to help Japanese students to identify English words with physical objects via the use of mobile devices which read, via RFID tags, the word corresponding to the object. Another application is the English vocabulary learning system which uses WLAN positioning technologies to identify the learner’s location. Given the learner’s location, time for learning and individual abilities, it adapts appropriate learning content to learners in order to promote learner interests and performance. In relation to mobile social networking, a few studies have been proposed. For example, an adaptive e-learning system which supports collaborative learning based on a location-based social network and semantic modeling by [68].

There are also several studies that have been carried out in relation to computing context. The rapid advancements in mobile and wireless communication technologies has seen variety of mobile devices, embedded and invisible devices, as well as the corresponding software components being developed. This has resulted to mobility coupled with diversity which has engendered new requirements to the human computer interaction (HCI) software community. The dynamic environment sets special requirements for usability and acceptance of context-aware systems [5].

In abstract architecture of context-aware systems formulated by [5], the computing context includes network infrastructure and device usability issues which according to their architecture, they fall in two different layers, thus the network infrastructure layer and user infrastructure layer. Several researches as [5] notes, have been conducted to offer appropriate network for providing context-aware computing especially involving the implementation issues. In TEL, tailoring learning experience that is adapted to learning needs and that suits learner's preferred device usage, rather than a 'one size fits all' approach has been a focus of several researches. Their fundamental concern has been on how the educational activity can be able to be performed by various types of learners, and to operate on various devices, networks and environments. Correspondingly, the devices and the networks to be able to support various educational activities in any environment [9] hence accommodating learner with different network and device conditions in one session [70].

Notably, the usability requirements for example the need to construct and maintain versions of single applications across multiple devices, check consistency between versions for guaranteeing a seamless interaction across multiple devices and the ability to dynamically respond to changes in the environment such as network connectivity, user's location, ambient sound or lighting conditions as mentioned in [71], has led to the proposal of the notions of adaptability and plasticity to address some of these requirements. In their study [72] proposed a device-independent architecture for mobile learning, which provides contents based on characteristics of mobile devices and mobile learners. Thus, delivering contents intended to adapt to not only learner's needs, but also to mobile device used. They used an adaptive design approach with the objective of constructing an adaptive m-learning system architecture. The system could detect features of mobile device and provide adaptive contents for mobile device and recommend adaptive contents for learners after analyzing their learning profiles and social networks.

The notion of plasticity was introduced by [73, 71]. Plasticity addresses the diversity of contexts of use by adaptation. Applied to HCI, plasticity is the capacity of an interactive system to withstand variations of context of use while preserving usability [73]. Applied to e-learning, plasticity describes the ability of a digital learning space to retain suitability for learning in different, changing contexts i.e. context of learning [47].

Generally, most of the context-aware systems as noted in [6] have been focusing on the external dimension of context. Addressing device usability aspect for example the ability of device and user interfaces (UIs) to adapt to different contexts of use is useful to cope with the learner diversity in terms of device characteristic the learners use. Likewise, addressing the physical context is also important, and very useful for context-aware systems, because as [5] states, context-aware systems provide recommended services for a person based on analyzing the external data. However, in order to achieve effective learning that increases learner satisfaction, it is not enough for learning to take place anytime and anywhere but there is also need to provide learners with learning experiences that are tailored to their particular educational needs and personal characteristics in order to cater for different individual needs.

2.2.4 Adaptation and Personalization in Addressing Learner Diversity Challenge

There are currently research initiatives in this domain. For example, the notion of adaptation and personalization has widely been proposed as an approach that can provide learners with learning experiences that are tailored to their particular educational needs and personal characteristics. Adaptation according to [74] refers to the process of enabling the system to fit its behavior and functionalities to the educational needs (such as learning goals and interests), the personal characteristics (such as learning styles and different prior knowledge) and the particular circumstances (such as the current location and movements in the environment) of the individual learner or a group of interconnected learners.

The adaptability of the learning environment to different contexts during the learning process promotes greatly effective learning. As noted earlier the context in which learning occurs varies from learner to learner due to individual differences. The learners more so in a DL environment produce heterogeneous needs under various contexts. Furthermore, with the emergence of mobile and pervasive technologies, these technologies do not only provide mobile users with unprecedented possibilities to learn on the move, but the device themselves are diverse in the capabilities. As a result, the diversity has been further broadened due these mobility and heterogeneous characteristics of current technology. Given such diversity, the traditional one-size-fit-all approach towards learning resources is no longer suitable in the e-learning paradigm. Although e-learning has evolved from one-size-fits-all system to adaptive and personalized learning system, the adaptive learning contents are not suitable to study because e-learning systems do not take into account their various contextual diversities [12]. As [75] points out, the challenge is not only to make information available to people at any time, at any place, and in any form, but specifically to say the right thing at the right time in the right way. The fundamental issue is how to provide learners with the right material at the right time in the right way [47], while providing personalized learning services in order to cater for learner individual needs amidst this great diversity.

In their study, [13] argued that in order to provide learners with suitable learning materials in such mobile settings, the learners' characteristics and context should be considered. Therefore, they proposed an approach for providing personalized course content in mobile settings. They considered a combination of students' learning styles and context. Context in their case referred to user's environment like location, light etc. Other studies in this area include [14, 69] who designed a Context-aware and Adaptive Learning Schedule (CALS) tool. The tool was designed to focus initially on supporting first year computer science undergraduate students to become more proficient Java programmers. It made use of a learning schedule, where the learners input their daily activities. Based on this information, the tool was to automatically determine the contextual features such as the location and available time. The appropriate learning materials were selected for the students according to, first, the learner preferences (such as learning styles), and secondly the contextual features (such as the level of concentration).

One of the recent works in this area is by [74] who developed a context-aware adaptive and personalized mobile learning system, called the Units of Learning mobile Player (UoLmP). The system was aimed at supporting semi-automatic adaptation of learning activities which included the adaptations to the interconnection of the learning activities (namely, the learning flow) and the adaptations to the educational resources, tools and services that support the learning activities. The tool was to be able to automatically detect contextual information such as place, time, and in some cases physical conditions according to the user situation. It was to also let the user input contextual information that was not possible to be detected automatically.

These studies [13, 69, 74] relied on external context (like location) and static user profile (like the learner's schedule) in providing appropriate learning materials to the learner. However, catering for individual learners' needs as well as satisfy learners needs require more than external context and static user profile.

Personalization through Cognitive Context

Cognitive domains, such as information retrieval, decision making, situation monitoring among others are very much needed in order to provide personalized services according to for example user preferences, task and emotional state of user among others. Cognitive context information is the key in satisfying user needs by providing personalized context-aware computing services [5]. Though as [5] argues some of the literatures which focus on cognitive context have been introduced, it is insufficient to establish context-aware systems that reflect cognitive context. However, from a pedagogical perspective, there seems to be a growing interest in such domain like emotions and affect. As [15] notes, recently, a growing body of literature has begun to espouse the central role of emotion to any learning endeavor and outcomes, especially in online learning. Continuous and increasing exploration of the complex set of parameters surrounding online learning reveals the importance of the emotional states of learners and especially the relationship between emotions and effective learning.

Emotion recognition is one of the key steps towards affective computing. Many efforts have been taken to recognize emotions using facial expressions, speech and physiological signals. Physiological measures are more difficult to conceal or manipulate than facial expressions and vocal utterances. They are also potentially less intrusive to detect and measure. Therefore, they are a more reliable representation of inner feelings and remain the most promising way for detecting emotions in computer science [15, 5]. Though there exist some computing systems capable of displaying immediate reactions to people's feelings by incorporating a combination of both emotion detection and emotion synthesis, however, as [15] notes, so far, most research on emotions does not bridge the gap to learning. The extension of cognitive theory to explain and exploit the role of affect in learning is still in its infancy. Never the less, some studies have been or are being carried out in this domain. An example is the study by [15]. Using emotion detection technologies from biophysical signals, [15] explored how emotion evolves during learning process and how emotion feedback could be used to improve learning experiences. They proposed an affective e-learning model, which combined learners' emotions with the Shanghai e-learning platform. They built an experimental prototype of the affective e-learning model to help improve students' learning experience by customizing learning material delivery based on students' emotional state. The goal of their study was to understand how learners' emotions evolve during learning process, so as to develop learning systems that recognize and respond appropriately to their emotional change.

Gaps in the Studies

Though the highlighted studies have contributed greatly towards this domain, however they exhibit a couple of shortcomings some of which this study attempts to address.

One of the limitations in these studies and a main shortcoming in context-awareness application is on the utilization of internal dimension of context. Though these studies like [13, 14, 69, 74] aim at providing learners with learning experiences that are tailored to their particular educational needs, however, their approach is adaptive in nature and runs shot of providing personalized learning. They still focus on external dimension of context and they majorly use static learner profile to depict the personal attribute of the learner. Though the use of static learner profile is important, however some learner attributes like emotions tend to be dynamic or change hence they need to be considered. Furthermore, though external dimension of context has resulted in some interesting, and useful applications, these approaches generally do not provide support for more cognitive activities. Cognitive context information is an important element for achieving user satisfaction since it provides personalized context-aware computing services [5, 6]. Cognitive domains utilize internal dimension of context like users preferences, goals, tasks, emotional state among others.

Though [15] study has considered internal context in form of learner's emotions, however the shortcoming in this study, which also cuts across typical context- aware studies (system) in general is obtrusiveness. It is easy to embed technology in the physical environment but not in a human body. In particular, the acquisition of sensor data and context information, from the investigated sensors devices, such as multiple body-worn sensors as well as vision and audio based sensors, may be often seen as obtrusive and can bring inconvenience and discomfort to the users [7] or may require the user to alter his or her normal habits and lifestyle. For example in [15] study, they used biosensors. The subject could not be allowed to move greatly because of being 'wired'. Even though the experiment took place in the subject's regular place of study, he had some "unnatural" feelings because of being 'wired'. In addition, he had to remember to report his emotion changes, which he considered as interruption to his learning. If a context-aware system is found obtrusive to a user, either from the perspective of hardware or software, it is likely that the user is reluctant to adopt that system [7]. Furthermore, such innovations or approaches may not always be practical for the daily lives of the users. In addition, collecting reliable affective bio-data can be challenging in that a few factors could affect the reliability of the biosensors. For example in [15] experiment, whether the subject just washed his/her hands, how much gel he/she applied under an electrode, how tight the electrodes were placed, and even the air humidity could affect the readings. One of the challenges in designing and developing a context-aware system as pointed out by [76] is to have a system that fulfills user's needs and at the same time ensure user's acceptance for the systems.

Another shortcoming particularly in [15] study is the experimental design. Though the research setting could be considered to be more natural and closer to the real-world settings compared to other experiments, their experimental design had also some short falls especially if it is considered to be applied in a DL environment. For example in their study, they used a single subject experimental design with the argument that the reliability of single subject experiment can be ensured by using reliable instrumentation, repeated measures, and also by describing the experimental conditions in details. Considering the versatility of the variables being studied (i.e., emotion), it seems appropriate to use one-subject design in this preliminary experiment. However, given the learner diversity, this experimental approach may not be reliable and realistic in real learning scenario. What is more, as the authors themselves acknowledge, emotion is often subjective and even the subject might not be completely aware of his/her own feelings. Further still, the same emotion could elicit different physiological patterns from different subjects. Furthermore, even though, a repeated measure of one subject in a longer period of time ensured consistent interpretation of the variables (emotions), however given learner diversity in a DL learning environment, the response from one subject may also not apply to all learners.

Lastly, the most outstanding shortcoming of these studies is the lack of or limited learner involvement. The studies' adaptation approaches to enhancing the learner experience limits learner's involvement in the learning process. As pointed out earlier, absolute machine control is not always desirable considering the intellectual characteristics of the end-users. By automatically making a decision or providing learning materials to the learner based on contextual information and user profile without allowing the learner to decide whether actually the provided material accommodates his or her needs, this in its very essence derives the learner the power to be involved in their learning.

Conceptual body of literature suggests that learner engagement is one of crucial elements for the successful realization of learning that is satisfactory to the learner. It is inevitable in achieving effective learning. This is not only as [2] argues, because software intelligence remains insufficient to enumerate and address all eventualities, it is also because of the intellectual presence of the human-beings. It is not possible to consider human beings as a piece of software that will function efficiently when fed by appropriate data more so in a learning scenario. For this purpose, end-user situation awareness, perceived user control and self-expressiveness hold a crucial role [2]. E-learning should not only generate good learning outcomes, but also better engage learners in the learning process. From engaged learning perspective, truly engaged learners are behaviorally, intellectually, and emotionally involved in their learning tasks. Engaging learners in the learning process brings along many benefits. They include as presented in [16] a more responsive and higher quality offer that empowers learners in shaping their own experience and the delivery of improved outcomes for more learners. Excellent teaching and learning which meets the needs of learners, and an understanding of the most effective ways to engage the learner result in a more satisfying and positive experience of learning, along with improved success [16].

2.3 In Addressing the Learner Engagement Challenge

The aforementioned criticisms suggest that, in order to achieve learner satisfaction in TEL, there is need for an efficient approach that caters for the learners' needs without altering their normal habits and computing devices i.e. ensuring unobtrusiveness. There is also need for an approach that engages them behaviorally, intellectually and emotionally in the learning process. The learner should take an active role while at the same time ensuring that individual learner needs are met amidst learner diversity.

Learner engagement as used in this study refers to a mutually beneficial interaction that results in participants feeling valued for their unique contribution [77]. Thus the person 'engaged' is an integral and essential part of a process, brought into the act because of care and commitment [78]. Though learner engagement is sometimes used synonymously with learner involvement or/and participation however, engagement is more than just participation or involvement. In fact, involvement implies many of the qualities of an interaction included in the definition of engagement and as [77] notes, the distinction between involvement and engagement seem to be grounded in the act of mutual benefit.

Learner engagement is a two sided affair. The learner need be active and engaged in the learning process as an independent leaner as well as in a collaborative environment. In this section, we look at two approaches that have been used to enhance learner engagement at an individual and at a collaborative level respectively.

2.3.1 Learner Engagement through Recommendation

Individual learners need to be active and fully engaged in the learning process as independent learners. In that, instead of automatically having entities in the learners' environment intelligently adapting to their situation without their involvement, learners can be engaged in the learning process by being involved in making decision about what and how they prefer to learn. One of the approaches that has been applied to achieve this is through use of recommendation mechanisms.

Overview on Recommender Systems in TEL

Apart from facilitating the identification and retrieval of suitable resources from a potentially overwhelming variety of choices, recommender systems in TEL offer a promising approach that gives the learner the power to decide based on their preference. This does not only enhance learner involvement in the learning process but offer a platform for personalized learning.

In the TEL domain, a number of recommender systems have been introduced. A survey on recommender systems in TEL by [79] indicates that most of these systems suggest learning resources. Other systems that have been introduced include course recommenders and systems that suggest people who can help with a learning activity. Another aspect worth noting are the particularities of TEL for recommendation. This area as [80] points out, offers some specific characteristics that are not met by today's general purpose recommendation approaches. For example, the information retrieval goals that TEL recommenders try to achieve are often different to the ones identified in other systems [79]. Others include usage data availability, heterogeneity in learner needs [80] and pedagogical issues [79] among others. Therefore, in order to make recommendation tailored to individual learner needs, hence personalize the learning experience, there is need as [80] notes, to take the context of the learner into account in a much more specific way than applied in today's recommendation approaches. Relevant contextual information does matter and as [81] states, it is important to take this information into account when providing recommendations. As a result of these particularities in TEL, the application of context-aware recommendation systems is currently being explored.

2.3.2 Learner Engagement through Collaborative Learning

Another approach that has been used widely towards learner engagement is collaborative learning (CL). CL is an educational approach to teaching and learning that involves groups of students working together to solve a problem, complete a task, or create a product [82]. It requires students to interact with other students to attain educational goals. According to proponents of CL as noted in [82], the fact that students are actively exchanging, debating and negotiating ideas within their groups increases students' interest in learning. Student work is more motivated, efficient, active and intensive due to lowered inhibitions and an increased sense of purpose. They also argue that CL encourages critical thinking. Students can perform at higher intellectual levels and student performance is enhanced [82, 83]. Apart from academic achievements, CL has been said to promote socialization, teamwork, planning abilities, reliability, presentation and moderation skills, self-confidence and also learners learn to be responsible [82, 83, 84].

This approach has been proposed to be ideal in educational setup especially in the present digital age where social networking and connectivity is the order of the day. CL for example through peer learning may adapt constructivist and connectivity methods. It is in line with Connectivism view that the knowledge we can access by virtue of our connections with others is just as valuable as the information carried inside our minds. The learning process, therefore, is not entirely under an individual's control—learning can happen outside ourselves, as if we are a member of a large organization where many people are continuously updating a shared database. In a joint paper, [85] argued that educational institutions should consider "emergent learning," in which learning arises from a self-organized group interaction, as a valuable component of education in the Digital Age.

With the benefits of collaboration in education being clear and with the rapid development of online learning in higher education, the use of technology to facilitate CL is vital. There have been several innovative means to include and ensure effective CL in online learning environment. One of the ways that has been effective in supporting and enhancing peer interaction has been through discussion forums. As a result, online discussion forums have become an integral part of teaching and learning in higher education [86]. Though discussion forums are commonly used tools to foster CL, however, simply establishing a discussion forum as [86] points out, does not necessarily bring about effective interaction or CL. There have been considerable challenges involved in designing discussion forum that can support desired learning outcomes. The two key challenges that have been noted as pointed out in [87] include ensuring participation and ensuring quality engagement.

Participation has been claimed to be an intrinsic part of learning [17]. In online learning, it has been argued by [88], that online participation underlies online learning in a more powerful way than any other variable. It has equally been argued by [17, 19] that participation influences learning outcomes, learner satisfaction and retention rates positively. Needless to say as [17] notes, there appears to be a convergence of opinion among researchers on the hypothesis —that online participation is a key driver for learning. However, the question as to why some students are active in forums but most are not still remains. Several reasons have been given as possible cause of low participation. Several approaches have also been suggested in order to encourage learner participation.

For example, the possibility of losing track of the threaded discussions has been seen as a major issue especially with asynchronous learning [86, 87, 17]. For instance, required regular discussions with a large class can result in long conversations as noted by [87] and the quantity of the message can overwhelm the learners to navigate through. Furthermore, keeping the discussion threads lively and informative is also a challenge to course designers and educators as [86] points out.

A couple of studies have also pointed towards the instructor and the instruction process as key determinants in learner participation in online discuss forums. For example, [89] argued that interactivity in online relates directly to instruction, therefore, there is need for "fine tuning" of the control of interaction within the instructional process. Mokoena in [90] is also of the view that discussion forum effectiveness and student interaction are increased by greater social presence on the part of lecturers. Xia and colleagues in [87] suggested that some kind of careful and creative instructor orchestration is vital to creating a quality environment of trust, risk-taking and respectful critical dialogue. Similarly [91] argued that the instructor needs to model participation, create assignments that encourage it, and foster an environment that supports it. As also part of instructor's role, assessing discussion forums is another approach that has been suggested to encourage participation [86, 17]. It has been noted by Abawajy in [86] that participation which can be measured by the frequency of interaction with peers and teachers have a positive effect on perceived learning, grades and quality of assignments. Abawajy [86] further suggested that assessing participation recognizes students' workload and time commitment with respect to online discussions and encourages students to participate in required learning activities associated with the discussions.

Delayed feedback has also been sighted as another cause for drop in participation rate since late responses have negative effect on the vitality of a discussion forum [17, 19]. Timely feedback that would allow learners to improve their contributions through their study is crucial. Similarly, it has also been found that formative feedback and authentic assessment are excellent ways to encourage quality participation and interaction that facilitates the sharing of knowledge and creates a community of inquiry [17, 19].

Small-group Collaborative Learning

Looking at literature, it is evident that most studies that have been conducted seem to focus on the instructor's role in facilitating participation. However, the workload pressure faced by instructors in online discussion forums tends to be high. This expectation to provide timely feedback, assess discussion forums among other demands as noted by [17] creates real dilemmas for instructors as they juggle other pressing responsibilities and time demands. They then end up spending a large amount of time on marginal tasks instead of focusing on the most vital teaching activities.

Therefore, establishing an environment in which the students are active and independent learners in the collaborative sense is crucial in avoiding the dependency on and reduced workload for instructors that may characterize more instructor-focused forums [86]. Furthermore as [92] notes, it is not sufficient to simply have interaction, but that the interaction must be structured and systematic if a collaborative process of critical inquiry is to be initiated and sustained. It is clear, however, that there are constructive strategies being used to develop structured student-directed approach to enrich participation. One of the approaches is through small-group learning in a collaborative environment otherwise referred to as cooperative learning. Cooperative learning is a form of CL which utilizes small-groups [84]. In cooperative learning, students work together in small-groups on a structured activity. They are individually accountable for their work, and the work of the group as a whole is also assessed. Among several benefits of small-group CL include greater student participation in comparison to whole group discussions, more peer- to-peer interaction and a richer knowledge construct through discussion posts [19]. Cooperative learning has also proved useful in large class size environments. When discussion groups are relatively small, high-quality sharing are more common, whereas larger groups are likely to cause student frustration and a feeling of discussion overload [19]. Having smaller groups is more personal, easier to follow, and students can then engage with each other in more meaningful, deeper, and more critical discourse [19, 84]. Because there are more exchanges among students in small-groups, students receive more personal feedback about their ideas and responses. This feedback is often not possible in large-group instruction like in Massive Open Online Courses (MOOCs). (In this thesis, the term cooperative learning will be used interchangeably with small-group CL).

Effective Group Formation

Although the advantages of small-group CL are well documented, studies indicate that the structure of groups has an impact on group productivity and effectiveness [18, 83, 86]. The quality of the online discussions in terms of the relative responsiveness of individuals, improvement in individual performance, the positive effects of fostering knowledge exchange among the peer and the educational benefits a learner gets through group learning depend strongly on the suitability of the selected peers in a group [18, 83, 86]. Abawajy [86] asserts that it is the composition of group members (i.e. the allocation of students into groups) that takes into account inter-working ability among members, which seems to be important in forming effective groups. In fact [83] claims that many of the unsuccessful outcomes from group work stem from the composition process. Therefore establishing effective opportunities for this form of CL in online environments requires care in creating groups, structuring learning activities, and facilitating group interactions [86].

According to [93], effective learning in groups must have at least the following elements: they must include every member of the group; each person has a valid job to perform with a known standard of completion; each member is invested in completing the task or learning goal and each member is accountable individually and collectively.

In order to achieve effective learning groups, different approaches have been proposed. One of the approaches that has been used is the *ability–grouping*. The most common formations based on this approach are homogeneous and heterogeneous grouping. Homogeneous groups are groups organized so that students of similar instructional levels are placed together, working on materials suited to their particular level, as determined through assessments [94]. Heterogeneous groups on the other hand are groups that include students with a wide variety of instructional levels. They stem from the education precept that a positive interdependence can arise from students with varied learning levels working together and helping each other to reach an instructional goal [94]. According to [94] heterogeneous groups can be contrasted directly with homogeneous Groups and vice versa.

The ability-grouping issue has generated a great deal of research, about the benefits or weaknesses of heterogeneous and homogeneous grouping. Both groups have been considered to have their own strengths and weakness when used alone. However some have proposed that it beneficial to consider both characteristics when forming a group. Johnson [93] argues that if given a choice, students prefer to learn in groups of their peers and friends (homogeneous groups), but they also appreciate getting to know and learn from other members of the classroom. This requires that we trust students to make good decisions and we hold them accountable for following the norms of learning in groups. Yang and colleagues [95] are also of the view that some aspects of personality should be heterogeneous within a group, while the other aspects of personality should be homogenous. As in nature, at the same time there are also two cases of "like attracts like" and "opposites attract".

Apart from ability-grouping, other criteria for assigning members a group have been proposed. The commonly used methods as presented in [83] include: *Random Assignment, Self-selection, Specific criteria and Task appointment.*

The *Random Assignment* criteria is where by as the name suggests members are randomly selected for example when each student is assigned a number or letter and then groups are formed by putting the students with the same numbers or letters together. Some of the advantages of this criterion as cited in [83] are that it is relatively easy to administer and it allows one to work with people they ordinarily would not. It is also seen by some students as being relatively fair. However, some of its drawbacks include the fact that students feel they do not have any choice in the selection process and they also worry about the chance of being assigned to a group with incompatible members. In *Self-Selection,* students are asked to form groups by themselves. This method is also easy to administer and students like the opportunity to choose their fellow group members. However, it may not yield a desirable level of diversity. *Specific Criteria* on the other hand attempts to form heterogeneous groups. It works on the assumption that groups work better when the members are balanced. Some of the more popular methods use functional roles, learning styles or personalities. With this approach, students see themselves as "experts" and are motivated to demonstrate and apply their skills; they learn about individual differences and how diversity can create teamwork. However, the group composition process might be expensive and time consuming. In *Task appointment criterion,* the teacher offers the students a number of topics and lets them select. Groups are then generated from the topics selected. The advantages of this approach are that students are more motivated for group work when they choose their own topic; they feel that the selection process of the group is fair and they know they will be working with people who are also interested in the topic and have confidence. The disadvantages of the approach may be that occasionally, there are too many students wanting to do a particular topic and not enough members selecting others.

Learner Grouping in Online Learning

Though the research on learner grouping in online learning is still in infancy, currently, there are studies being carried out on creating effective groups. For example, [83] in their work developed a software tool that automatically groups learners based on their personality attributes and performance level. The experimental results confirmed that students grouped based on level of performance and personality attributes perform best as compared to randomly-assigned or self-selected groups. Bekele [83] is of the view that automatic grouping that considers personality attributes and performance level can be a viable grouping technique to create effective groups. The study by [95] proposes a learning grouping algorithm based on user personality for users to learn in groups. In their study, they modeled the learner personality based on learning interests, learning capability, learning style, learning activity, sex and age.

Though [95] approach considers both homogenous and heterogeneous factors of personality, however, [95, 83] studies and similar studies in this area do not capture the learner's sociological attributes or social personality. When it comes to learners' personality traits in terms of learners' preference to learning, the commonly used preference in most studies including [95] is based on sensory preferences (i.e. visual, auditory, and kinesthetic). However, an individual's preference to learning also encompasses other learning preferences. They include, as presented in [96], environmental, emotional, sociological, psychological and physiological preferences. Furthermore, group learning is a CL approach and social presence is the basis for CL [18]. Therefore, the authors argue that the learner's social personality should be the basis of any form of group allocation. This aspect has been overlooked by researchers in this area. There has been limited research focusing on social personalization in CL and no work to the author's knowledge has considered the use of sociological preference as a basis for group formation, hence the focus of this study.

2.4 Summary

This chapter first provided a background on sound pedagogical practices by reviewing learning theories and frameworks. The integration of pedagogy with technology in TEL with a focus on DL was then discussed followed by an overview on personalization. The application of context-awareness in educational set-up was then examined. In particular the nation of adaptation as used in selected studies to provide learning that is tailored to learners' educational needs was reviewed. The chapter also discussed the issue of learner engagement by first providing a background on learner engagement, then a discussion on approaches that have been used to achieve learner engagement. Particularly the use of recommendation and collaborative learning were discussed. In collaborative learning approach, the chapter focused more on the small-group collaborative approach. Selected studies on online learner grouping were examined. The chapter identified gaps in the selected studies. The next chapter, presents the approaches employed by this study to address some of the aforementioned gaps in the reviewed studies. The aim is to enhance personalization and learner engagement in context-aware collaborative learning environment.

Chapter 3

3 Integrating Pedagogy and Technology, Enhancing Personalization and Enhancing Learner Engagement in CALE

This chapter presents the study's approach for achieving its goals. It is organized in three sections. The first section describes the formulation of a framework for integrating technology and pedagogy in context-aware learning environment (CALE). The second section discusses the study's approaches for enhancing personalization and enhancing learner engagement within the formulated framework. The last section presents the implementation of a personalized and engaging context-aware learning environment (PECALE) software tool.

3.1 Integrating Pedagogy and Technology in CALE

The use of context-aware technologies for learning and teaching brings optimism and opportunity for education. However, as [21] notes, it also challenges us to consider the best possible uses of these technology in the process of exploiting technology for pedagogical advantage. These two i.e. technology and pedagogy have to be properly integrated in order to achieve effective learning. On the other hand, the mobility, heterogeneity and dynamism attributes that normally characterize context-aware technologies are transforming the learning environment. However as transformation arise in TEL educational set up as a result of these technologies, so does the challenge arise of understanding and applying sound pedagogical foundation in utilizing these technologies for effective learning. It is imperative as noted in *section 2.1* that the pedagogy continue to transform and evolve as technologies change. As also revealed in the same section, pedagogy is the cornerstone of effective learning in any learning environment. Therefore, it is should be considered when using or designing a CALE.

This study attempted to explore how CALE can be rooted in a pedagogical foundation. The aim was to formulate a framework that offers a platform for the integration of pedagogy and technology in a CALE. Existing literature was extensively reviewed to guide the formulation of the framework. Based on the review of the existing literature, the author argues that in order for CALE to be rooted in a sound pedagogical foundation as well as cater for the diverse learner needs, the following building blocks should be its guideline: i) Ensuring sound educational practice, ii) Addressing the uniqueness of DL in the case of DL environment, iii) considering context in which learning occurs, and iv) personalizing learning. These building blocks are summarized in Figure 3.1 and explained in details below.

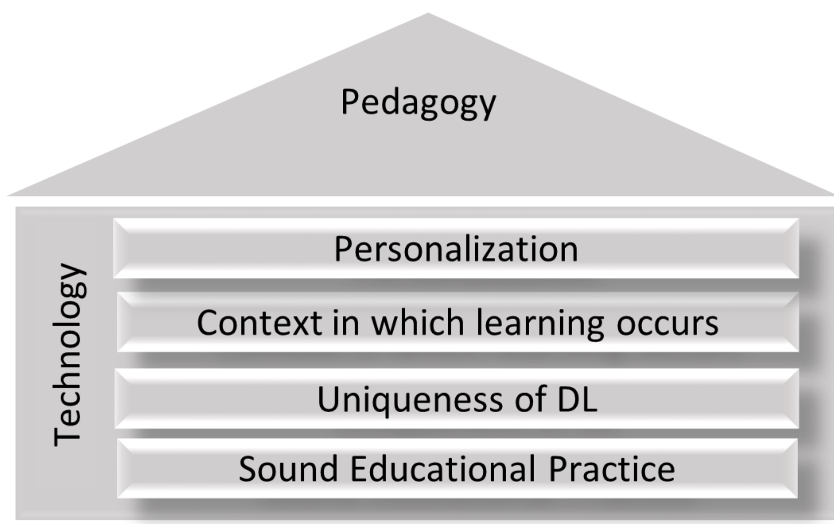

Figure 3.1 Building blocks for the integration of pedagogy and technology in CALE

3.1.1 Ensuring Sound Educational Practice

Whether the learner is at the center or part of a learning community or learning network, learning effectiveness is important. Learning effectiveness as stated by [22] can be greatly enhanced by applying, at a detailed level, an understanding of how people can learn more effectively. In addition, to cater for diverse learner needs, it is crucial to develop a richer means of establishing both collaborative and personal learning environments. An environment that offers control when needed in both pedagogical and organizational terms. Therefore, each learning theory – behaviorist, cognitivist, constructivist, and connectivist (explained in *Section 2.1.1*) – plays an important role. A good designer does not strictly apply only one theory when designing, rather, it is important to consider the specific learning task in relation to the approaches. For example, introductory knowledge acquisition is better supported by approaches from behaviorists and cognitivists as noted in [25]. Cognitivist and behaviorist models are most notably theories of teaching. These models provide a strong structure to learning that makes explicit the path to be taken to knowledge. When done well, these (i.e. cognitivist or behaviorist) approaches help the learner to take a guided path towards a specific goal as noted by [22].

A constructivist approach is very ideal when there is a need for the learners to master more complex problems and acquire higher-level thinking skills as noted by [25]. Constructivist models place an emphasis on scaffolding, although in a manner that is more conducive to meet individual needs and contexts. What they lose in structure, they make up for in dialogue. The social-constructivist approaches for instance, rely heavily on negotiation and mediation to help the learner from one state of knowledge to the next. The social presence is rich in these models. They are more notably theories of learning, but translate well into methods and processes for teaching [22].

Importantly, the designers and educators should also be open to emerging trends in learning theories. The advancement of technology has reorganized how we live, how we communicate and how we learn. It has transformed the whole aspect of learning in that learning as noted by [22] has now changed to a continual process in which knowledge transforms into something of meaning. This is made possible through connections between sources of information and the formation of useful patterns - a view supported by connectivists. Connectivist models as noted earlier are more distinctly theories of knowledge which makes them harder to translate into ways of teaching. However, this makes them ideal approach in this information age where it is believed that knowledge comes from a variety of domains and disciplines.

Therefore, there is need for a framework comprising of well balanced and integrated learning theories which support a learning community with the teacher presence, cognitive presence, and social presence. There is also need for a framework that supports active learning while accommodating individual learners' differences. The study argues that, integrating theories of teaching as represented by the behaviorist and cognitivist, theory of learning as represented by constructivist and theory of knowledge as represented by connectivist leads to a well-rounded educational experience that ensures effective learning.

To capture and achieve a well-balanced synthesis of these learning theories, the current study adopted the instructional framework by Saskatchewan Education [30] which has been described in detail in *Section 2.1.1*. As discussed in the same section, a clear understanding of the instruction framework is the beginning of sound and successful educational practices, whether on campus or in a DL environment. The instructional framework is heavily influenced by learning theories. The Saskatchewan framework adopted for this study provides a guideline on the integration of interrelated levels of approaches. These levels of approach include: instructional models (which reflect learning theories), instructional strategies, instructional methods and instructional skills (for details, refer to Figure 2.1). Though they have been described in details in *Section 2.1.1,* a quick overview of these levels is presented below.

Instructional models represent the broadest level of instructional practices and presents a philosophical orientation to instruction. They are used to select and to structure instructional strategies, methods, skills, and student activities for a particular instructional emphasis [30]. They are related to learning theories. *Instructional strategies* determine the approach a teacher or instructor may take to achieve learning objectives. Several strategies can be used within each model as explained in *section 2.1.1*. *Instructional methods* are used by teachers to create learning environments and to specify the nature of the activity in which the teacher and learner will be involved in during the lesson. *Instructional skills* are the most specific instructional behaviors. These are used constantly as part of the total process of instruction. Among the factors which may influence their selection and application are student characteristics, curriculum requirements and instructional methods.

3.1.2 Addressing the Uniqueness of DL Environment

DL environment comes along with its uniqueness, like the separation of the teacher and learner, mobility, technology and learner diversity among others. Furthermore, the diversity aspect has even been further broadened due the mobility, dynamism and heterogeneity characteristics of context-aware technologies. The technology the leaners use and the physical environment they may be in during the learning process may differ from learner to learner because of these characteristics. Therefore the context in which learning occurs varies greatly among learners in that, apart from the diversity in the personal attributes of these learner, their work is distributed in time and place.

On the other hand, DL has been described as a changing paradigm, one that is constantly evolving. It has evolved through many technologies, theories and pedagogies. This special attribute of DL presents pedagogical challenges. As noted in *section 2.1.2* no single theory has provided all the answers amidst the paradigm shift in DL. One of the most serious issue faced by emerging DL environments like m-learning as stated by [11] is the lack of a solid theoretical framework which can guide effective instructional design and evaluate the quality of programs that rely significantly on these technologies. On the other hand [10] argues that one of the main issues in applying these technologies in creating new models of learning is not technical, but social because of insufficient understanding of pedagogical application outside the classroom. In [49], it has been claimed that the changing and diverse environment in which DL is practiced has been the main reason that has inhibited the development of an all-inclusive single theory upon which to base practice and research.

Though there may not exist a theory that may provide all the answers for the changing and diverse DL environment, however, as [97] proposes that a comprehensive framework needs to be developed from the exploration and study of DL and the best practices of learning therein. Therefore, in an attempt by the current study to develop this framework, the existing theories and frameworks that have been developed over the years in DL were reviewed. These theories though not inclusive, they have offered guidance in achieving effective DL learning environment in their respective technological eras. The study identified theories with elements which, if properly integrated offer guidance in addressing the uniqueness of DL in CALE extensively. These are the *Activity theory* and the *Transactional distance theory* (These theories are explained in detail in *Section 2.1.2*). The *Activity theory* was proposed because as noted by [52], it can be used as a lens to analyze learning processes and outcomes for the design of a mobile learning environment. Besides, it is powerful framework for designing constructivist and learner-centered learning environments. Most importantly, it provides the design of context-aware applications. All these attributes are applicable in a CALE. *Transactional distance theory* on the other hand was proposed because of its usefulness as a pedagogical and philosophical framework that is useful in understanding DL. Besides, it has the capability to capture the influence of communication media on transactional distance. The theory encompasses both organizational and transactional issues without losing sight of the learner, the institution and the organization, as noted by [25]. Furthermore, one of the variable of *transactional distance theory* is learner autonomy, i.e., a learner can have control or have a decision over learning procedures, activities and processes. The fact that learners can have self-directness, this can lead to personalized learning.

The two theories complement each other in that the combination of the two theories brings out the strength of each theory and eliminates the weakness of each. For example, one of the limitation of the *transactional distance theory* is the inability to explain the individual's social characteristics. This renders it impossible to capture the social aspects of learning and newer forms of social technologies. On the other hand, *activity theory* incorporates this aspect.

Park's pedagogical framework (PPF) [11] which this study adopts uses several elements of the *Activity theory* to modify transactional distance theory. PPF was designed for m-learning, which embraces both learning with portable technology, and learning while on the move. These two aspects require context-awareness for them to be effectively achieved which makes PPF to be applicable in a CALE. Though the framework is explained in detail in *Section 2.1.2,* here is an overview on how the framework integrates the elements of *transaction distance theory* and *Activity theory* to bring out the best of them as well as how it can be applied in a CALE.

PPF adopts the original concepts of *transactional distance theory* but modifies it by adding a new dimension to support both individual and social aspects of learning. Park [11] argues that due to the recent developments of emerging communication technologies, structures of learning are built not only by the instructor or instructional designer as depicted by transactional theory but also by collective learners. Furthermore, dialogue is not only formed between the instructor and learners, but also among the learners themselves. In order to consider the importance of the social aspects of learning as well as newer forms of social technologies, Park's framework has an individual versus collective (or socialized) *activities* dimension.

According to PPF, individualized and socialized activities are mediated by communication technology. Both *transactional distance theory* and *Activity theory* consider mediation to be important. By integrating some of the *Activity theory* elements into *transaction distance theory,* [11] generated a conceptual and pedagogical framework based on high versus low transactional distance and individualized versus socialized activity. This dimension that indicates the range of individualized to socialized activity can be a useful lens for reviewing diverse learning activities. Applying PPF, the four types of learning activities that can be generated in DL environment mediated by context-aware technologies as illustrated in Figure 3.2 include (1) high transactional distance socialized context-aware (CA) learning, (2) high transactional distance individualized CA learning, (3) low transactional distance socialized CA learning, and (4) low transactional distance individualized CA learning.

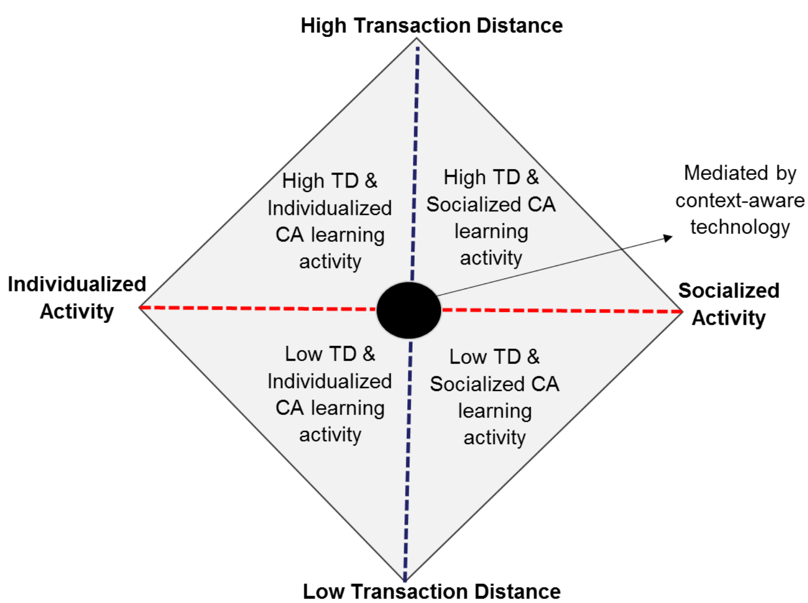

Figure 3.2: Adopting PPF in CALE (modified from [11])

3.1.3 Considering Context in which Learning Occurs

Learning always occurs in context [52]. This is because learning is interwoven with other activities as part of everyday life. These activities as [37] states can be resources and contexts for learning. As [52] notes, it is impossible to separate the learner, the material to be learned and the context in which learning occurs. Context situates the learner within an environment from which the senses continually receive data that are interpreted as meaningful information and employed to construct understanding [37].

Furthermore, context in which learning occurs varies from learner to learner due to the individual differences. This is because, a part from personal attributes, the technology the leaners use and the surrounding they may be in during the learning process may differ from learner to learner. Therefore, being aware of the context in which learning occurs offers the potential to cater for different learners needs.

Context provides information about the present status of people, places, things and devices in the environment [5]. As discussed in *section 2.2*, it has been noted to be key in providing learning that is tailored to learners needs. Taking learners' situation, educational needs and personal characteristics otherwise referred to as context into consideration is crucial in generating appropriately designed learning experiences. It is also key in offering instruction that is paced to a learner's unique needs. Furthermore, with learning taking place in a rich environment, there exist overwhelming resources available for learners to choose from. Therefore the identification and retrieval of suitable resources for individual learners based on their needs is vital in achieving effective learning. In order to recommend suitable learning material to the learner, there is a need to take the context of the learner into account. Therefore, considering the context in which learning occurs is vital in addressing the diversity challenge since it offers a platform to tailor learning experience to individual learner's needs.

With current technologies like mobile and ubiquitous technologies having context-awareness capabilities and with their effectiveness and efficiency relying heavily on the context of users, this makes it possible to integrate context-awareness in TEL.

Since context is an open concept, this study derived its context dimensions from the factors that influence learners' decision to drop out of DL programs as presented in *Section 2.1.2.* This was aimed at addressing the diversity challenge as well as addressing the uniqueness of DL in CALE. The factors were categorized into issues to do with the learner, computing and physical environment. Translated into context, the study referred to them as *physical context*, c*omputing context* and *learner context*. Therefore, in this study, *physical context* refers to the real world or surrounding of learning activities e.g. objects, persons, events which are peripheral to the learning activities but affect the learner's behavior or influence the learning process. *Computing context* refers to the artifacts or tools that mediate 'learning' activity i.e. the technology used to mediate learning. The computing context captures aspects like device usability and the communication infrastructure. Involves both the hardware and software platform(s) that can be used for interacting with the system. The *learner context* reflects learner profile and the cognitive state or internal state of the learner. It refers to aspects about the learner like the learner's preferences, goals, tasks, emotional state among others. These contexts i.e. *physical*, *computing* and *learner context* are classified into two major categories. They include *external context* (which comprises of *physical context* and *computing context*) and *internal context* (which mainly comprises of *learner context*).

3.1.4 Personalization of Learning

Much about personalization and its pedagogical benefits have been discussed in *Chapter 2*, however it is important to highlight that personalization is key in satisfying learners needs and creating engaged learner. This is because, in addition to responding to the learners' needs and interests, personalized learning as stated in [62] teaches them to manage their own learning. It allows them to make suggestions and control their own academic experiences. They are involved in the creation of learning activities. Instead of education being something that happens to the learner, it is something that occurs as a result of what the learner is doing as explained by [62]. As a result, it creates an engaged learner. Therefore in personalized learning, learning is not only tailored for the learners but also by the learners in order to meet their different learning needs and aspirations.

Typically, technology is used to facilitate personalized learning environments. Context-aware technology promises great potential in providing personalized services due to its context-aware capability. Since personalized learning relies more heavily on the learner's personal interests and innate curiosity, considering internal dimension of context like the learners' preferences, goals, tasks, and emotional state among others is key in providing personalized learning in CALE.

3.1.5 Context-aware Learning Environment Pedagogical Framework

In summary, in order to ensure that CALE is rooted in a pedagogical framework the following should be realized - ensuring sound educational practice; addressing the uniqueness of DL environment; considering the context in which learning occurs and personalizing learning. Therefore the study used these elements as building blocks in formulating a CALE pedagogical framework. The overview of the framework is presented in Figure 3.3. Figure 3.3 depicts how components that influence learners' decision to persist or drop out of DL programs in relation to Figure 2.3 were translated into context. Parks' pedagogical framework (PPK) and the instructional framework are presented as pedagogical wheels guiding the implementation of sound pedagogical practices in a CALE. Figure 3.4 presents the detailed view of CALE Pedagogical framework.

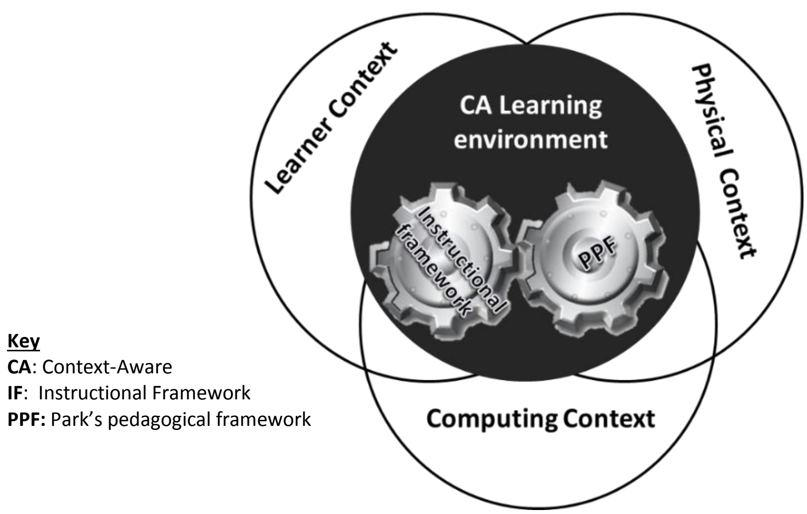

Figure 3.3: Overview of CALE Framework

The framework as presented in Figure 3.4 comprises three layers. The first layer offers the pedagogical foundation. This layer integrates learning theories which serve as the foundation block of the framework and instructional strategy as adopted from the Saskatchewan instructional framework [30]. The layer also links different context-aware learning activities as adopted from PPF [11] with possible instructional strategies. The second layer is the personalization layer which acts as the mediator between the pedagogical layer and the context layer which is the top layer. The personalization layer ensures that learning is tailored to learner's needs, interests, preferences, and pace by the learner and for learners based on the contextual information received from the context layer. The third and final layer is the contextual layer which presents context in which learning occurs. It is responsible for offering contextual information. In the framework, the contextual dimensions as explained were derived from factors that influence learners' decision to persist or drop out of DL programs. Therefore the context in this framework comprises learner, physical and computing contexts. Computing and physical contexts reflect the external dimensional of context. Learner context reflect the internal dimensional context.

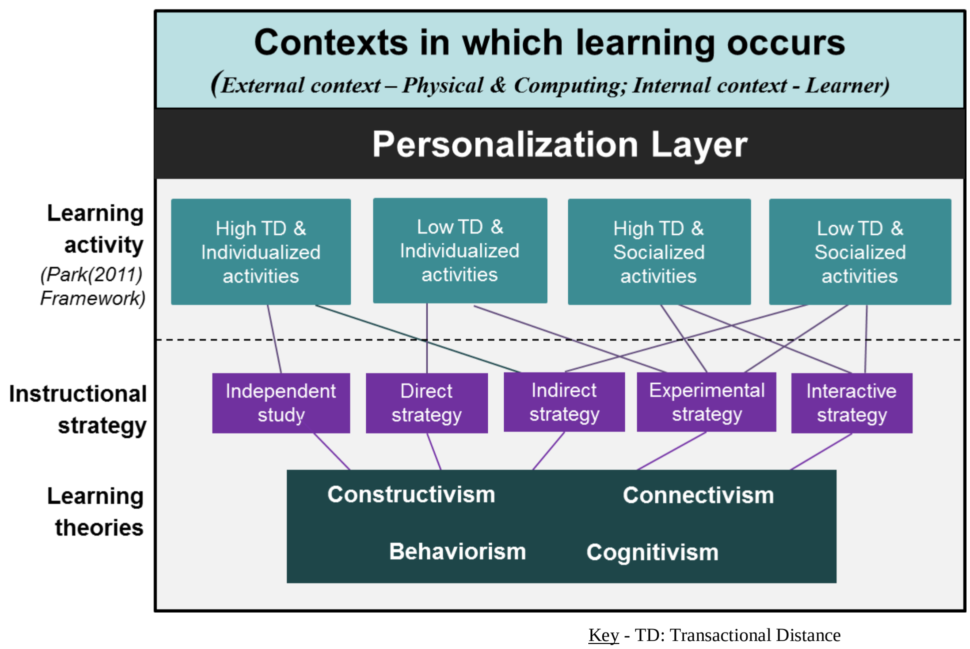

Figure 3.4: CALE Pedagogical Framework

The formulated framework was conceptual and guided the study toward implementing a personalized and engaging CALE in an attempt to address the learner diversity and learner engagement challenges. The study's approaches to enhance personalization and learner engagement were integrated in the framework as explained in the section that follows.

3.2 Approaches for Enhancing Personalization and Learner Engagement in CALE

As it has been argued in the previous sections, it is not enough to provide learning that is tailored to different needs of learners. However, it is of great importance for the learners to also be involved in providing this experience otherwise referred to as personalization. Providing a personalized learning experience is key in satisfying learner needs. Furthermore, learner engagement is vital for the successful realization of learning that is satisfactory to the learner. Therefore, the next goal of this study was to enhance personalization and learner engagement in a CALE. Personalization in essence is a broad concept. Therefore, in order to explore in depth the study's approaches to enhance personalization and carry out a manageable experiment within the study's stipulated time, the scope of personalization in this study was limited to social personalization.

To enhance personalization, learning preferences as context in which learning occurs were explored. In particular, the learners' sociological preferences to learning were considered as the basis for social personalization. To enhance learner engagement, two approaches were applied. Context-aware recommendation mechanism was applied with the aim of engaging individual learners through decision making. A structured small-group CL approach was used to enhance learner engagement in CL environment. In particular, sociological preference similarity strategy was used in group formation. These approaches were integrated within the formulated CALE framework. The integration of these approaches into CALE resulted into the implementation of PECALE (a Personalized and Engaging Context-aware Learning Environment). These approaches are explained below.

3.2.1 Consideration of Learning Preference as Context in which Learning Occurs

The rational for the need of context and why it should be context in learning has been explained in detail in *Sections 3.2.3,* however, to emphasize on its importance, it is vital to note that learning always occurs in context. In addition, learners' needs differ from individual to individual. As a result, context in which learning occurs may vary from learner to learner due to these individual differences. Studies have been carried out and context-aware applications developed in an attempt to enhance the learning experience by adapting to the learners' situation without their involvement. Though this can provide learning experiences that are tailored to learners' particular needs, however, as discussed in sections *2.2* and *2.3*, lack of learner involvement is not always desirable. Engaging learners in the learning process is vital in achieving effective learning that is satisfactory to the learner. As also noted, there is limited focus on the internal dimension of context in current context-aware applications. Considering the internal dimension of context like learners preferences, goals, tasks, emotional state, among others, provides personalized context-aware services. This is key in providing personalized learning in CALE. Personalized learning approach has been proposed to provide learning that satisfies learner needs. This is because it not only provides learning that is tailored to the preferences and interests of various learners, as well as instruction that is paced to a learner's unique needs, but also engages the learner in creating this experience.

Why Learning Preference as Context?

The learner's preference to learn is considered as internal dimension of context. As already highlighted, consideration of internal context is vital in providing personalized services. The preference of each learner is different according to learner context and profile. It is claimed in [98] that there are probably as many ways to teach as there are to learn. Perhaps the most important thing is to be aware that people do not all see the world in the same way. They may have very different preferences on how, when, where and how often to learn [99]. A person's individual preference to how to learn (which is also sometimes referred to as learning style) is an important key for reaching learning potential. How learners learn is as important to consider as the content being taught. Learner-centered education strives to make both content and methods appropriate for the learner [100].

According to [101], a learning style (also referring to learning preference in this study) is a student's consistent way of responding to and using stimuli in the context of learning. Keefe in [102] defines learning styles as the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment. They are those educational conditions under which a student is most likely to learn [103]. Thus, according to [101], learning styles are not really concerned with *what* learners learn, but rather *how* they prefer to learn. Thus as [101] further argues, they are not really *styles*, but rather *preferences* in that we do NOT learn best by using our style of learning, but rather we prefer one or more styles over others.

While how an individual prefers to learn is based primarily upon sensory preferences like auditory, visual, kinesthetic, and tactile components, it also encompasses other learner preferences. They include as presented in [104], the environment, emotional, sociological, psychological and physiological preferences. These aspects are summarized in Figure 3.5 adopted from [104]. Successful presenters as pointed out by [105] employ a variety of teaching strategies in response to the diverse set of learning preferences found within most groups.

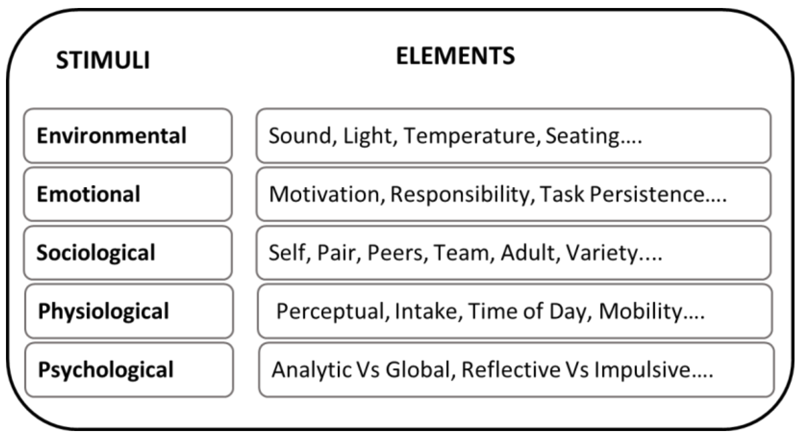

Figure 3.5: Learning preferences (modified from [104])

Considering learning preferences provides conditions that optimize learning for each learner. This makes it an important key for reaching diverse individual learner needs and providing personalized services hence satisfying learner needs. An individual's preference denotes in the best way their personal traits. Considering or capturing an individual's personality provides the best platform for understanding their needs. And understanding an individual's needs offers the best platform for providing personalized services. Moreover, consideration of learning preference offers a solution to obtrusiveness in context-aware systems. For example, instead of embedding technology into the learner's body to capture internal contextual data like emotions, such information can be captured from the learner in the natural way possible. For example through capturing emotional preferences from the learner. (The issue of obtrusiveness is out of the scope of this study so it will not be covered)

Furthermore, considering learner's preferences to learn positions the learner as the core entity in that, other contexts like the physical and computing context tend to revolve around or determined by the learner as shown in Figure 3.6. This in turn allows the learners to choose what accommodates their multiple needs depending on places and spaces across time or their present learning situation. Allowing learners to choose or involving them in decision making offers a platform for the learner to be engaged in the learning process.

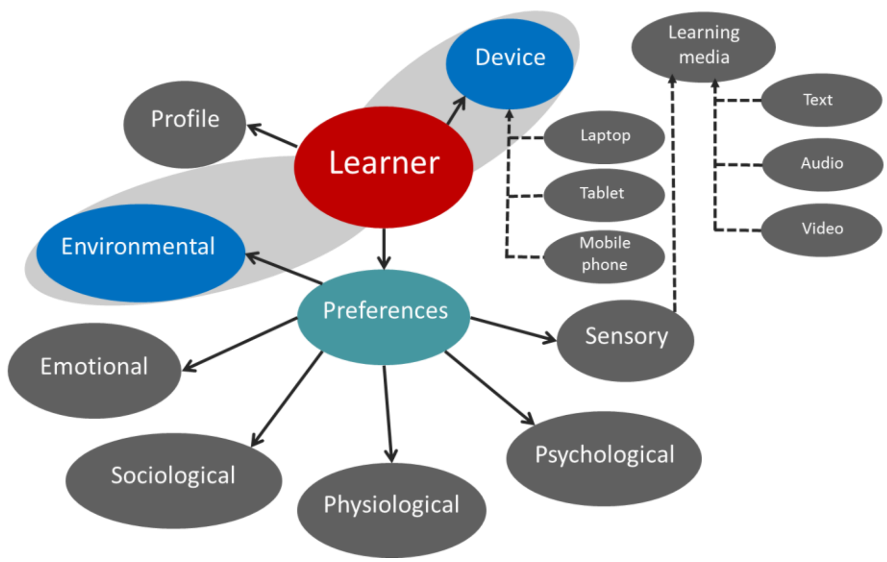

Figure 3.6: Learner as a core entity

Integrating Learning Preferences within CALE framework

Learning preferences were integrated in the formulated CALE framework at the contextual level under the learner context as shown in Figure 3.7. One of the advantage of CALE framework is that it provides the possibility to consider various dimensions of context. It can also allow one to focus on either one aspect of contextual information (like the learner's sociological preference as in this study's case) or several contextual information and dimensions (e.g. device, connectivity, location, preference etc.) all together. This attribute makes this framework to be an ideal framework within which any context-aware learning environment applying any contextual dimension can be implemented. This aspect of the framework made it possible for the study to focus on one contextual aspect within the study's scope. The study's scope was within learner context (i.e. internal dimensional context of the learner). Within learner context, learning preference in particular sociological learning preference was the focus of the study as highlighted in Figure 3.7.

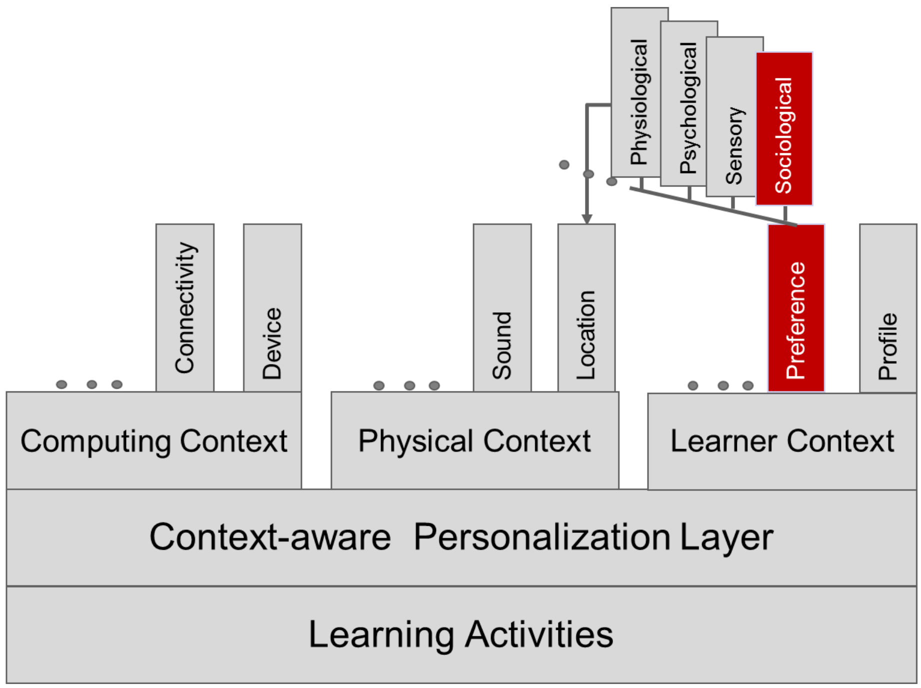

Figure 3.7: Integrating learning preferences as context within CALE framework

Sociological Preferences as the Basis for Social Personalization

Social presence has been sighted to be the basis for CL. Since social presence is the basis of CL, the author argues that learners' sociological preferences need to be considered for offering personalized services that come along with CL. For example the allocation of resources and collaborative partners among other things. Offering personalized learning in a CL environment based on the learner's sociological preference is what this study refers to as social personalization. Therefore, social personalization in relation to CL is defined in this study as *providing a CL experience that is tailored to the learner's sociological preferences and learning needs while involving the learner in creating this experience.*

Sociological learning preference involves preference for learning in groups, in pairs, or alone [96]. Highly social individuals prefer learning with others. However as [104] also notes, some learners are solitary in nature, and prefer to think and contemplate individually. In TEL environments like online learning platforms, current course models as noted in [106] are inclined toward self-directed learning which applies independent learning. They also apply group learning which is mainly achieved through discussion forums. Though these approaches are valuable, however, learners' sociological preferences are more than just this two categories. Not forgetting the aforementioned limitations of discussion forums. Putting into consideration the diverse sociological preference of learners in a CL environment leads to social personalization. Social personalization can be utilized in assigning collaborative partners to form effective learning groups.

This study attempted to diversify sociological preferences to offer the learner more options to choose from. The options were in terms of collaborative learning activities of different sociological preferences. The fact that the learners can be involved in decision making in terms of choosing an activity they prefer instead of it being automatically assigned to them, this engages them in the learning process. Furthermore, if the learners are involved in deciding how they would like to work on a collaborative activity in terms of sociological preference, this will in turn motivate the learners to freely contribute since they know that they are working with people with similar liking or interests. This kind of atmosphere leads to effective CL.

In this work, group and pair preferences were considered to offer more options in sociological preferences. Furthermore the learners' sociological preferences were considered as the basis for assigning collaborative partners and recommending learning activities (how group assignment and the recommendation of activities was implement is explained in *Section 3.3*).

3.2.2 Structured Small-Group Collaborative Learning Approach

In order to enhance learner engagement in a collaborative environment, this study employed small-group CL approach. The advantages of small-group CL and particularly its ability to achieve greater student participation are well documented. However the group productivity and effectiveness is highly determined by the structure of the groups [18, 83, 86, 82]. It has been claimed that many of the unsuccessful outcomes from group work stem from the composition process [83, 82]. Therefore establishing effective opportunities for this form of CL requires care in creating groups, structuring learning activities, and facilitating group interactions [86, 82]. Therefore, in an attempt to achieve effective learning groups with enriched learner engagement, this study employed a structured small-group-based approach based on social personalization. Sociological similarity preference strategy was used to form the small-groups and the learning activity flow was structured based on Kolb's experiential learning cycle.

Sociological Preference Similarity Strategy in Small-Group Formation

In this study, the learners' sociological preferences were used as the basis for forming the groups. The *"similar object attract each other"* characteristic was used to group learners with similar sociological preference. The argument behind this approach was based on similarity-attraction theory which attempts to explain and predict interpersonal liking by asserting that people are attracted to others who are similar to themselves. Consistent with this view, researches like [107, 108] has revealed that people prefer to affiliate with those who share similar characteristics compared to others who do not. They claim that people are not only inclined to be attracted to those who share similar attitudes, but they are also attracted to others who exhibit similar personality traits e.g., optimism, self-esteem, shyness, conscientiousness. Furthermore, it is believed that attraction to the group as a whole causes group cohesion [109, 110]. According to [18], group cohesion i.e. the development of a group identity and the ability of participants in the learning community to collaborate meaningfully is one of the main factors that allow for the effective projection and establishment of social presence. A group is said to be in a state of cohesion when its members possess bonds linking them to one another and to the group as a whole [111]. Members of strongly cohesive groups are more inclined to participate readily and to stay with the group. Based on these claims, the author argues that consideration of similarity in learners' sociological preferences may contribute to strong cohesion hence establishment of a strong social presence hence enhanced performance in a CL environment.

Using sociological preference similarity strategy as a basis for group formation provides a platform to integrate the main four group assignment criteria i.e. random assignment, self-selection, specific criteria and task appointment. As discussed in *Section 2.2.5*, these criteria, though they all have strengths but they also have limitations that make them not ideal to strictly apply one criterion throughout, rather, it is important to consider the specific learning task in relation to these criteria. In a traditional face to face classroom, it is possible to easily integrate this approaches by applying them in different situations. However this may not be the same with technology. This may mean developing a software for each assignment criteria which may be time consuming. Therefore, this study's approach to group formation may offer a solution to this dilemma. The approach adopts these assignment criteria while retaining their strengths and eliminating their limitations. *Section 3.4* explains how these criterion are implemented in PECALE. However, just an overview on how the approach works - in PECALE, grouping was done in two phases. The first phase employed specific criteria and task appointment criteria in assigning groups. It involved learners being grouped based on their sociological preferences. In this case, two categories of sociological preferences were considered namely learners with preference to learn in group and learners with preference to learn in pairs. Based on their similarity in preference, learners with preference to learn in a group were to be clustered together and the same with learners who preferred to learn in pairs as illustrated in Figure 3.8. The second phase involved grouping learners within the preference clusters formed in phase one. Within this clusters, random assignment and self-selection assignments were applied.

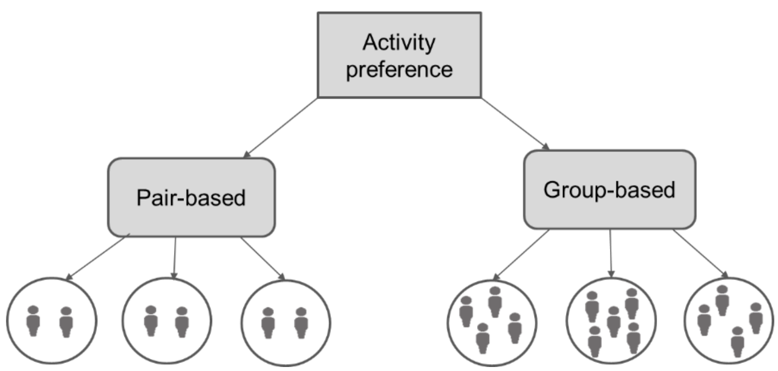

Figure 3.8: Grouping based on learners' sociological preferences

Integrating these criteria within the study's similarity strategy approach makes it possible to address both homogenous and heterogeneous aspects of the group. Both homogenous and heterogeneous aspects as discussed in the literature are important and should be considered in forming effective learning groups. However, in this study, the researcher argues that in a learning group, it is important to first determine whether the members within the group are socially compatible since social presence is ideally the basis of CL.

Hence, the study's emphasis on similarities in sociological preferences. It starts the grouping by considering these preferences (which captures the homogenous aspect of the group). However, the study's assumption was that the other attributes like learning capability, sex etc. within a similar sociological preference cluster should defer hence bringing the heterogeneous aspect within the group. The studies scope does not extend to other attributes of the learner within the group.

Structuring Learning Activity Flow based on Kolb's Model

As discussed in the literature review section, to achieve effective learning in groups, it has been cited in [93] that at least each person should have a valid job to perform with a known standard of completion, each member should be invested in completing the task or learning goal and each member should be accountable individually and collectively. In PECALE, this guidelines were observed by structuring the learning activity flow. The structure was designed based on Kolb's model [33, 34] with an extension on the active experimentation phase as shown in Figure 3.9. Kolb's model is expressed as four-stage cycle of learning consisting of concrete experience, reflective observation, abstract conceptualization and active experimentation stages.

The concrete experience phase as explained in [34] provides a basis for observations and reflections. These observations and reflections are assimilated and distilled into abstract concepts producing new implications for action which can be actively tested. This in turn creates new experiences. Ideally this process as [34] states, represents a learning cycle where the learner 'touches all the bases', i.e. a cycle of experiencing, reflecting, thinking, and acting.

Kolb's model offers both a way to understanding individual people's different learning preferences and also an explanation of a cycle of experiential learning [34, 33]. Furthermore the model's active experimentation phase provides a solid foundation for learner engagement. This in turn establishes an environment in which the students are active and independent learners in the collaborative sense. Furthermore, with the extension of the model's active experimentation phase, learners are presented with activities of which they are expected to achieve goals individually and collaboratively by the completion of any given learning activity phase. (How this structure is implemented in PECALE is illustrated in detail in Activity flow diagram in Figure 3.26)

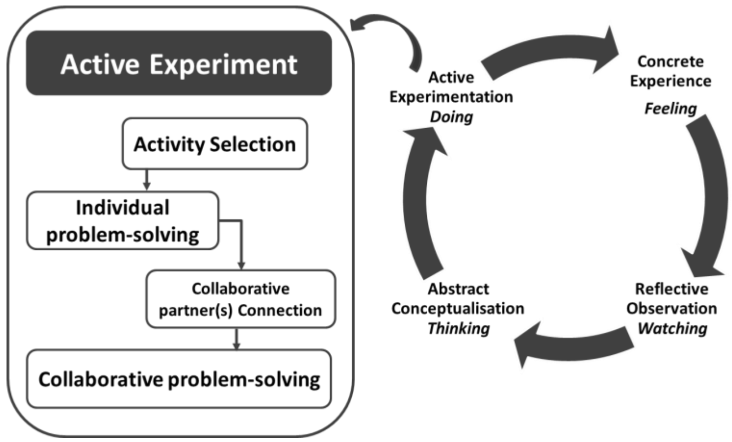

Figure 3.9: Learning activity flow within Kolb's model with an extension on the Active experiment phase

3.2.3 Applying Context-aware Recommendation

Learner involvement is not only in a collaborative environment, individual learners need to be also active and fully engaged in the learning process as independent learners since they are expected to achieve goals individually. Therefore, instead of adapting to the learners' needs without their involvement, learners can be engaged in the learning process by being involved in making decision about what and how they prefer to learn. One of the approach that has been applied to achieve this is through the use of recommendation mechanisms. Context-aware recommendation approach takes the context of the learner into account in a much more specific way. Taking relevant contextual information of the learner does matter in making recommendation tailored to individual learner needs, hence personalizes the learning experience. Furthermore making recommendations and allowing learners to decide on what best fits them instead of intelligently adapting to their situation without their involvement offers a promising approach for learner engagement.

PECALE attempted to apply basic context-aware recommendation approach to facilitate the provision of suitable learning activity type in terms of preference. In particular, sociological preference was considered as context in recommending learning activities. The contextual information (i.e. Sociological preference in this case) was obtained through inferring by observing learners' actions like activity selection and task submission and explicitly through learner feedback. The preference rating was used as the basis for recommending learning activity type (detailed explanation on how this was done is presented in the Implementation *section 3.3*).

In Context-aware recommendation, ratings are defined with the rating function as:

$$R: User \times Item \ \times Context \rightarrow Rating$$

Translated to our context as:

$$R: learner \times LearningActivity \ \times Context \rightarrow Rating$$

This study applied basic and minimal version of recommendation process since the study considered only one dimension of contextual information (i.e. sociological learning preference). However, the work was implemented within CALE framework which offers the possibility of extension. Therefore, in case of the extension of contextual domain, the contextual pre-filtering as contextual preference elicitation and estimation technique was proposed. In this technique, the activity selection is driven by the contextual information. Thus information about the current context is used to select the relevant activity. Based on CALE framework, if different dimensions of contextual information are available, the order of contextual pre-filtering is structured as illustrated in Figure 3.10. Where by, the order of filtering starts with device specific (computing context), followed by physical context e.g. location then learner preference (internal context). Therefore the contextual information from the different dimension is used to determine the appropriate learning activity type for the learner at that particular time.

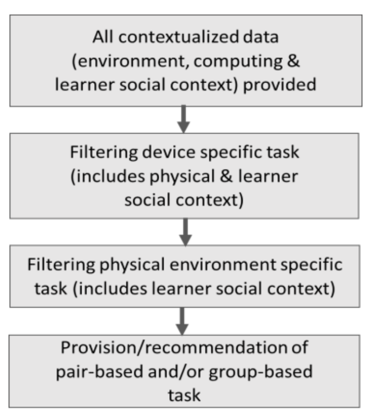

Figure 3.10: Order of Contextual pre-filtering

Another aspect considered in the study was the situations where relative preference might be required. For example in the case of extension in terms of use of several learning activities or/and monitoring of several learning behavior. In this study, only a maximum of three learning activities were used, therefore calculation of relative preference was not necessary. Instead, the total sum of rating was used for recommendation purposes (explained in detail in *section 3.3*). However, in cases of several learning activities and/or monitoring several learning behavior determining relative referencing is recommended. Therefore the study considered the relative preference algorithm shown in equation 3.1.

$$P_{ij} = \frac{P_{ij}^{s} - min_{1\le j\le |L|}\left(P_{ij}^{s}\right)}{max_{1\le j\le |L|}\left(P_{ij}^{s}\right) - min_{1\le i\le |L|}\left(P_{ij}^{s}\right)} + \frac{P_{ij}^{a} - min_{1\le j\le |L|}\left(P_{ij}^{a}\right)}{max_{1\le j\le |L|}\left(P_{ij}^{a}\right) - min_{1\le i\le |L|}\left(P_{ij}^{a}\right)} + \frac{P_{ij}^{b} - min_{1\le j\le |L|}\left(P_{ij}^{b}\right)}{max_{1\le j\le |L|}\left(P_{ij}^{b}\right) - min_{1\le i\le |L|}\left(P_{ij}^{b}\right)} \tag{3.1}$$

Where:

- P_{ij}^{s}, P_{ij}^{a} and P_{ij}^{b} is number of selection *s* action, individual task submission (ITS) *a* action and collaborative task submission (CTS) *b* actions made by learner *i* in learning cycle *j* respectively
- $max_{1\le j\le |L|}\left(P_{ij}^{s}\right)$, $max_{1\le j\le |L|}\left(P_{ij}^{a}\right)$ and $max_{1\le j\le |L|}\left(P_{ij}^{b}\right)$ is maximum number of sections, ITS actions and CTS actions made by the learner *i* in *L* cycle
- $min_{1\le i\le |L|}\left(P_{ij}^{s}\right)$, $min_{1\le i\le |L|}\left(P_{ij}^{a}\right)$ and $min_{1\le i\le |L|}\left(P_{ij}^{b}\right)$ is the minimum number of selections *s* actions, ITS *a* actions and CTS *b* actions.

3.3 The Implementation of PECALE

PECALE (Personalized and Engaging Context-aware Learning Environment) is a software prototype designed with the aim of enhancing personalization and learner engagement through context-awareness. PECALE was implemented within CALE pedagogical framework. The development environment for PECALE included HTML, JavaScript and Bootstrap for the front end, PHP and Canvas API for the back end and POSTGRE SQL for database.

3.3.1 The Need for a Learning Management System

In order to achieve a wholesome and rich learning experience in a typical TEL environment, several components are required. In most cases, this components are usually integrated together through a learning management system (LMS). A LMS is a software application for the administration, documentation, tracking, reporting and delivery of TEL education courses or training programs [112]. In order to provide a rich learning experience, this study needed a LMS. However, the design & implementation of a LMS is a complex process that requires time and considerable work. Therefore the study opted for an existing LMS. There already exist a number of LMS in use today for example MOODLE, Blackboard, and Canvas Instructure[1] among others. In this study, PECALE tool was integrated with the existing Canvas Instructure LMS [2]

3.3.2 Overview on Canvas Instructure

Canvas is a cloud-native, open-source learning platform and a LMS that is based on Ruby on Rails platform. It has open API (application programming interface) which makes it easy to integrate with other applications. Furthermore, it has a rich content editor that can be used to link various other pages. Since it is built using web standards, it can run on any common web-browsers. Also the LTI (Learning Tool Interoperability) enables a single tool to be used across several platforms .With the Account creation capability, usage of the complete functionality of the canvas system is possible but with well-defined space of access and modification. It can also be used as a LMS as well as a MOOC platform. Based on these attributes, Canvas provided an ideal platform on which PECALE's requirements could be configured. It also offered the possibilities to try out the developed tool in both private (small scale) and public (large scale) scenarios.

3.3.3 PECALE Architecture and Mode of Operation

PECALE was expected as its output to recommend learning activity to the learner and assign collaborative partners based on the learners' contextual information which in this case was the learner's sociological preference as shown in Figure 3.11.

Canvas was used as a basic portal that was responsible for the user login and authentication. Canvas itself allows teachers to create static assignments. However, it has

[2] canvas.instructure.com

no functionality to unite particular assignments with several learning activities options. Therefore, the teacher has no room to personalize learning activities or rather create diverse learning activities in order to cater for different learners preferences. One the other hand, students are not given any power to choose but rather complete all the tasks given in the course. PECALE addressed this aspect. In PECALE, the teacher function allowed the teacher to create a learning activity (LA) with two learning activity type (LAT) i.e. Pair-based & Group-based within Canvas' assignment function. Therefore an assignment was represented to the learner with two LAT namely pair-based and a group-based activity from which the learner could choose from based on their preference.

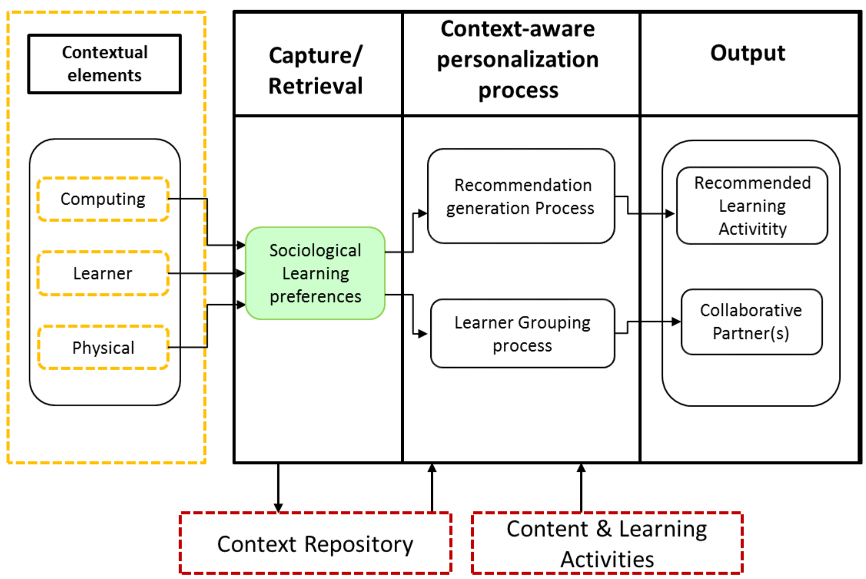

Figure 3.11: Overview of PECALE's System Architecture

Generally, the system requirements were as follows:

a) for the teacher to be able create various tasks that can be performed by learners with different sociological preferences
b) for the teacher to create tasks that can enable a learner to achieve goals both individually and collaboratively

c) for the teacher to be able to monitor learner behavior in terms of participation, activity preference and progress
d) for the learner to be able to choose a task,
e) for the leaner to receive an individual task
f) for the learner to receive a collaborative task
g) for the learner to be able to submit both individual and collaborative tasks
h) for the learner to be able to give feedback

To be able to achieve this, two separate views i.e. teacher view and student view were presented. But before looking at these view, let us first look at how PECALE was integrated with Canvas.

Integration and Interaction of PECALE with Canvas

PECALE was integrated with Canvas LMS as an extension to its assignment functionality. It was displayed differently based on who was working with the system i.e. a teacher or a student. This decision was based on the analyses of the parent page of Canvas from where the *user ID* was extracted. The data about course *ID* and assignment *ID* were to be received from the url-address of the Canvas parent page. In order to integrate Canvas system to the university's web-server, an additional step of adding the tag for the iframe shown in Figure 3.12 was needed. This tag was used to display a web page within a web page and with the use of this functionality all the users of this page could be re-direct to PECALE's web server's page. At this point, the user's role was checked. If the user was a teacher then the teacher view was provided. If it was the student then the student view was displayed.

```
<p><iframe  src="/test/code/project_10_08/first_page.html"  width="820"
height="1040"></iframe></p>
```

Figure 3.12: Tag for iframe

Teacher View

The Courses and the Assignments were created in Canvas and stored in the Canvas' main database. This was the first step of task creation. The rest of the process was re-directed to PECALE's web server page. PECALE's home page of the Assignment was to display all the options for the teacher to create the tasks. The options included Pair-Based (PB) activity type and Group-Based (GB) activity type as shown in the screen short in Figure 3.13. It was also to indicate the status of the task creations. The status reflected the steps the teacher required to follow when creating a LA.

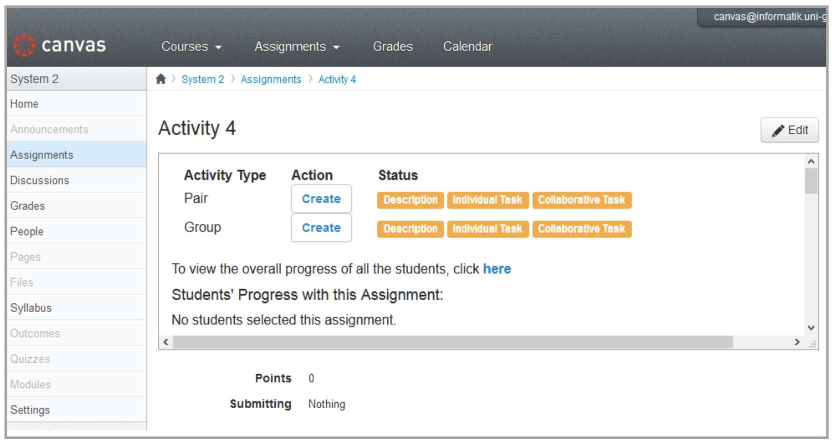

Figure 3.13: The activity creation page

The LA was designed based on Kolb's model discussed earlier in *section 3.2*. Both LAT were to have the same measure of objective. The learner was expected to achieve goals individually and collaboratively by the completion of any chosen LAT. Therefore, within each LAT, the teacher function allowed the teacher to create both an individual task and collaborative task for both LAT. This involved giving a generalized description of the activity itself, followed by the description for individual-based task and then the description for collaborative- based task as illustrated in Figure 3.14.

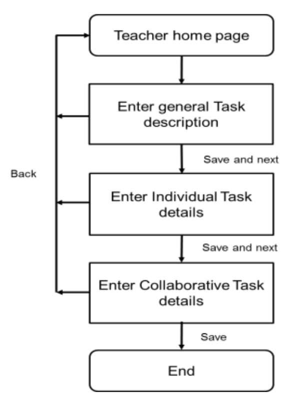

Figure 3.14: Logic flow for every LAT in teacher view

The teacher was also to be able to monitor learners' behavior. The students' progress and activity choice for every assignment (Figure 3.15) as well as overall students' progress and activity preference (Figure 3.16) were provided. This included information about the groups, members in a group, individual members and group progress among others. In the overall student progress display, details about individual students like participation in the respective LAT, progress in each LA among others were provided. Furthermore, the teacher had a functionality to grade students' assignments. This information was to be directly transferred to Canvas using Canvas Grades API.

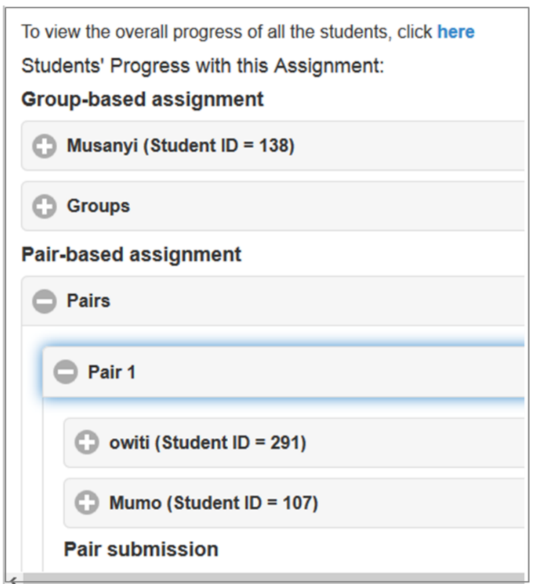

Figure 3.15: Students' Progress in a particular LA

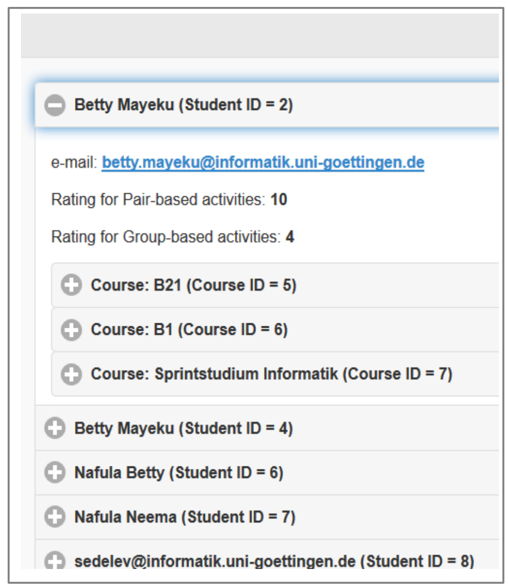

Figure 3.16: Overall students' Progress for all LAs

Student View

The first step for a new students was to register into the course. This was facilitated by Canvas student registration functionality. If the student was not new, they could directly log-in. After log-in, the student was to be able to view the LATs (both Pair type and Group type) without displaying the type itself. The student was to choose the LAT purely on the basis of its description and their preference or liking of the activity. If this was not the student's first log-in i.e. they had participated in other LAs previously, activity recommendation as shown in Figure 3.17 was to be provided at this step. The generation of recommendation was based on the learner's previous behavior (Recommendation process is explained in the recommendation process section below). However, the learner was at liberty to choose a LAT that was not recommended. After choosing the LAT, the learner was to submit the selection to be able to move to the next step. Every LAT had two steps, an individual task and a collaborative task. After the student had submitted the selected LAT, an individual task was displayed. After completion of the task, the learner could upload a file or comments fields or both and submit. After submission of individual task, collaborative partner(s) and collaborative task were to be provided. The student could start with the collaborative task only after submission of the individual task.

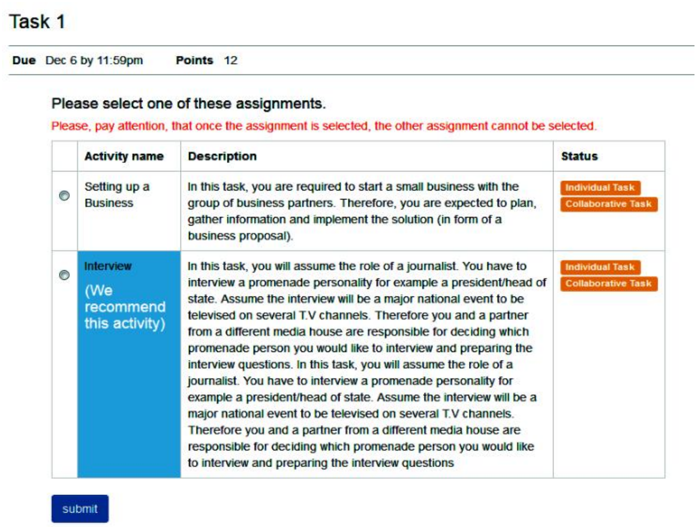

Figure 3.17: Example of set of LAT to choose from & a recommended activity

For the collaborative task, only one submission from any of the members was sufficient. However other members were to review and accept the submission for it to be completed. An example of how the individual and collaborative tasks were presented in PECALE is shown in Figures 3.18 and 3.19 respectively. Once the collaborative task was submitted, the students were invited to give feedback on that particular activity through feedback form that was displayed. The submission of feedback form marked the end of that particular LA cycle and the learner could then move to another LA. The system flow chart in Figure 3.20 and the overall LA workflow in Figure 3.22 depicts in summary this process.

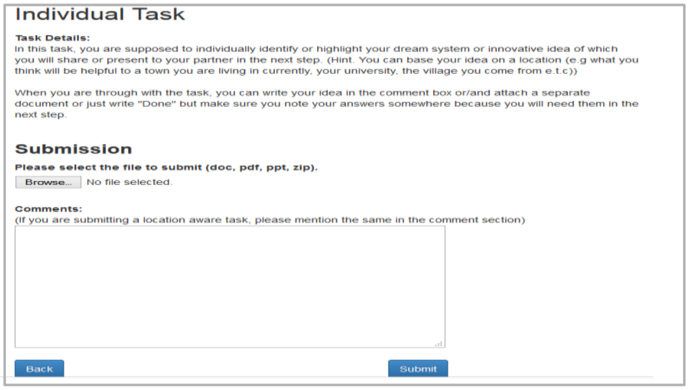

Figure 3.18: Example of an individual task as presented to the learner

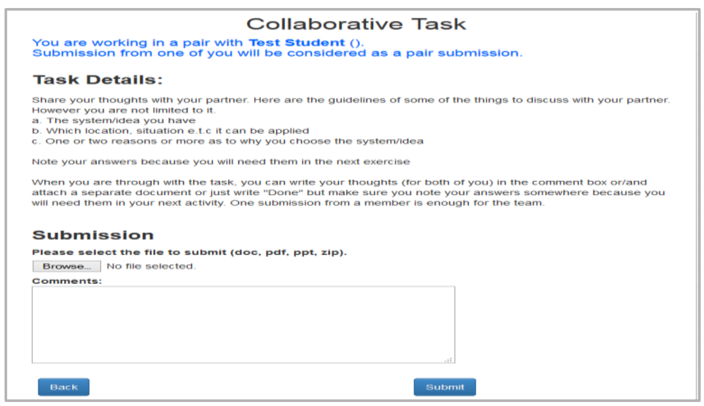

Figure 3.19: Example of a pair-based collaborative task as presented to the learner

Preference Rating for LAT Recommendation and Collaborative Partner(s) Allocation

As mentioned earlier, in this work, two sociological preferences namely group and pair were considered. Based on the learner's preference, a collaborative activity could either be pair-based or group-based. Pair-based LAT required learners to work in pairs (i.e. in twos) on a collaborative task. While a group-based LAT required learners to work in a small-group of minimum of three to a maximum of five students on a collaborative task. The student could only start working on a collaborative task after submitting the individual task as explained earlier. The contextual information i.e. sociological preference in this case was obtained by inferring through observing learner's behavior. Actions used for defining learners' behavior included: *Activity Selection*, *Individual Task completion* and *Collaborative Task completion*. The contextual information was also obtained explicitly through *Learner Feedback.* These actions and learner feedback contributed towards the learner's preference rating as illustrated in Figure 3.20. The rating value was then used to recommend a LAT to the learner.

Recommendation Process

In order to recommend the next LAT to a learner, the learner's previous behavior was considered by looking at the rating for both LAT i.e. Pair-based and Group-based in the learning activities the learner had previously undertaken. The recommender algorithm was to be triggered initially when the task was being chosen for the first time.

The rating details as illustrated in Figure 3.20 were as follows:

- When the learner selects a LAT this contributed to the rating value with a value of 0.5;
- Submission of the Individual Task for the selected LAT contributed to the rating value with a value of 1;
- Submission of the Collaborative Task for the selected LAT contributed to the rating value with a value of 1.5;
- The user feedback had maximum value of 2; all the questions had an equal rating value. The rating value for all the questions ranged from -2 (for maximum negative response to all the questions) to a maximum of +2 (for maximum positive response to all questions). The user feedback value was added to the overall activity rating.

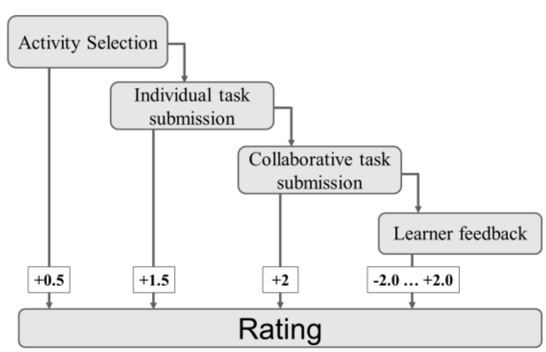

Figure 3.20: Actions for defining learner's behavior for rating

As a basic version, the algorithm summed up the rating for the particular user for pair-based activities and group-based activities separately. Comparison was made between the two values. The activity type with highest rating value was then highlighted and recommended. If the rating values were equal, then no recommendation was made.

Partner(s) Search and Pair/Group Assignment for Collaborative Task

After activity selection step, based on the selected LAT, learners with similar preferences i.e. learners who chose a group-based LAT were clustered together and learners who chose to learn in pairs i.e. selected pair-based LAT were also clustered together as it was illustrated in Figure 3.8 in *section 3.2.2*. This in turn formed two main branches thus pair-based and group-based clusters. The "First come first served" approach was used so that first priority was given to the learners who were available first (i.e. those who had already submitted individual task hence ready for collaborative task) within the two main branches. Within the group-based branch, if the minimum group number (i.e. 3) was reached, a 20 minute time span was given to wait for any other available person, if not available, the group was closed, if 1 or 2 more persons were available (i.e. 1 making 4 group members or 2 making 5 which is a maximum number) within the 20 minute time span, then they could join the group and then the group is closed. If several collaborative partners were available at the same time during the initial group formation, the learners could then be grouped randomly. In the case of group-based LAT, if by the time the leaner wants to work on a collaborative task and there already exist several groups that have not reached the maximum number and are not closed yet, the learner could choose a group to join. In this case, self-select assignment approach was used.

The "first come first served" approach was used to avoid wasting time while waiting for group members (for example one may want to work at 8pm and the partner or a group member is available at 11pm). Therefore, it provided an opportunity for leaners with similar working pace and working time span to continue working without being held back or being inconvenienced with slow or partners/group members who happen to have different working time. This was majorly significant in purely online learning setting where learning was distributed over time.

The study ideally employed the main four approaches to group assignment discussed in *Sections 2.2.5* and *3.3.2*. These criteria were implemented as illustrated in Figure 3.21 as follows: the specific criteria was used in the sense that learners were clustered into two main groups based on their sociological preferences. The task appointment criterion was employed due to the fact that leaners were offered different LATs to select from and eventually two main clusters were generated from this selection.

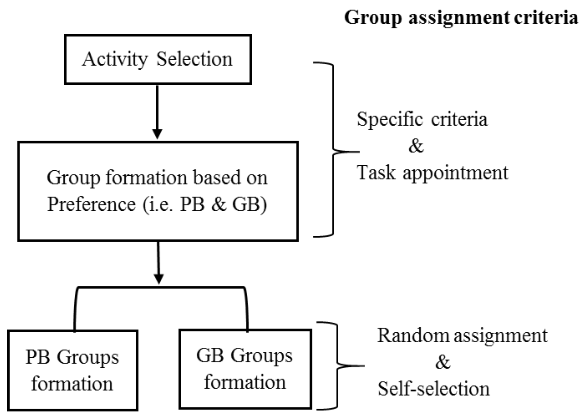

Figure 3.21: The application of different group assignment criteria in assigning groups

Within the two main clusters i.e. pair-based and group-based, random assignment and self-selection criteria were employed. The random assignment criteria was applied in situations where several collaborative partners were available at the same time during the initial group formation as mentioned earlier. The self-selection criterion was applied specifically in group-based in the situation where several groups were available that had not reached maximum number and were still open for the learner to join. Therefore, the student could choose an already existing but not full group. This made it possible for learners to work with people outside there cycle of friends but still had a choice on who they preferred to work with. Figure 3.21 summarizes this steps and the respective criterion applied in each step.

PECALE’s partner (s) search functionality was to look for students that had the same status and similar preference i.e., they were signed in the same course and assignment, they had submitted an individual task, they had similar sociological preference, and they had not found a partner or partners yet (for the case of group-based). After the submission of individual task, if potential collaborative partner(s) were available, the list of available students was provided as shown in Figures 3.22 and 3.23. If no one was available, this was also made known to the student. Once a student had found enough partners (or a pair), the group was then allowed to start working on a collaborative activity.

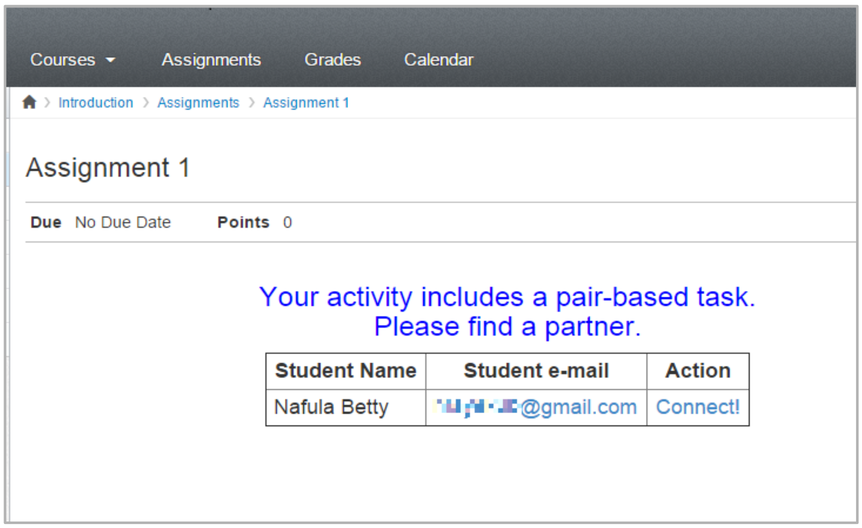

Figure 3.22: Example of connecting with collaborative partner in a pair-based scenario

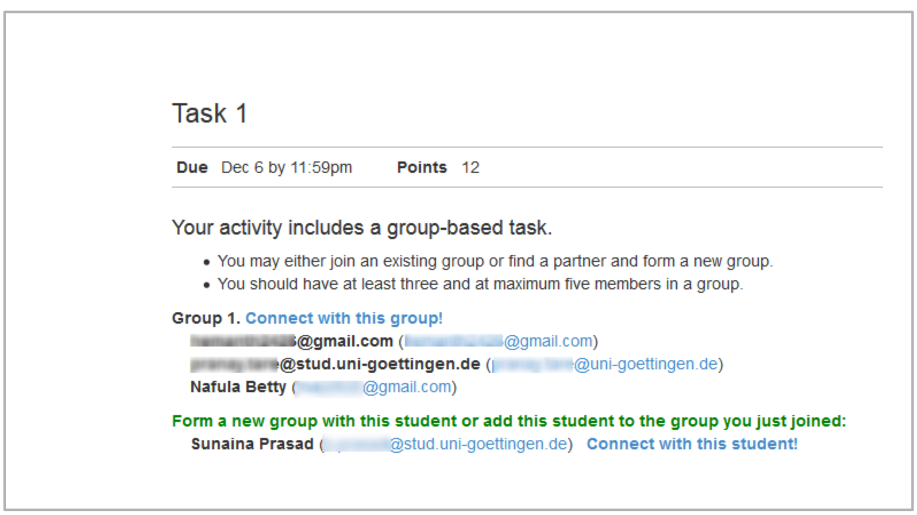

Figure 3.23: Example of connecting with collaborative partner in a group-based scenario

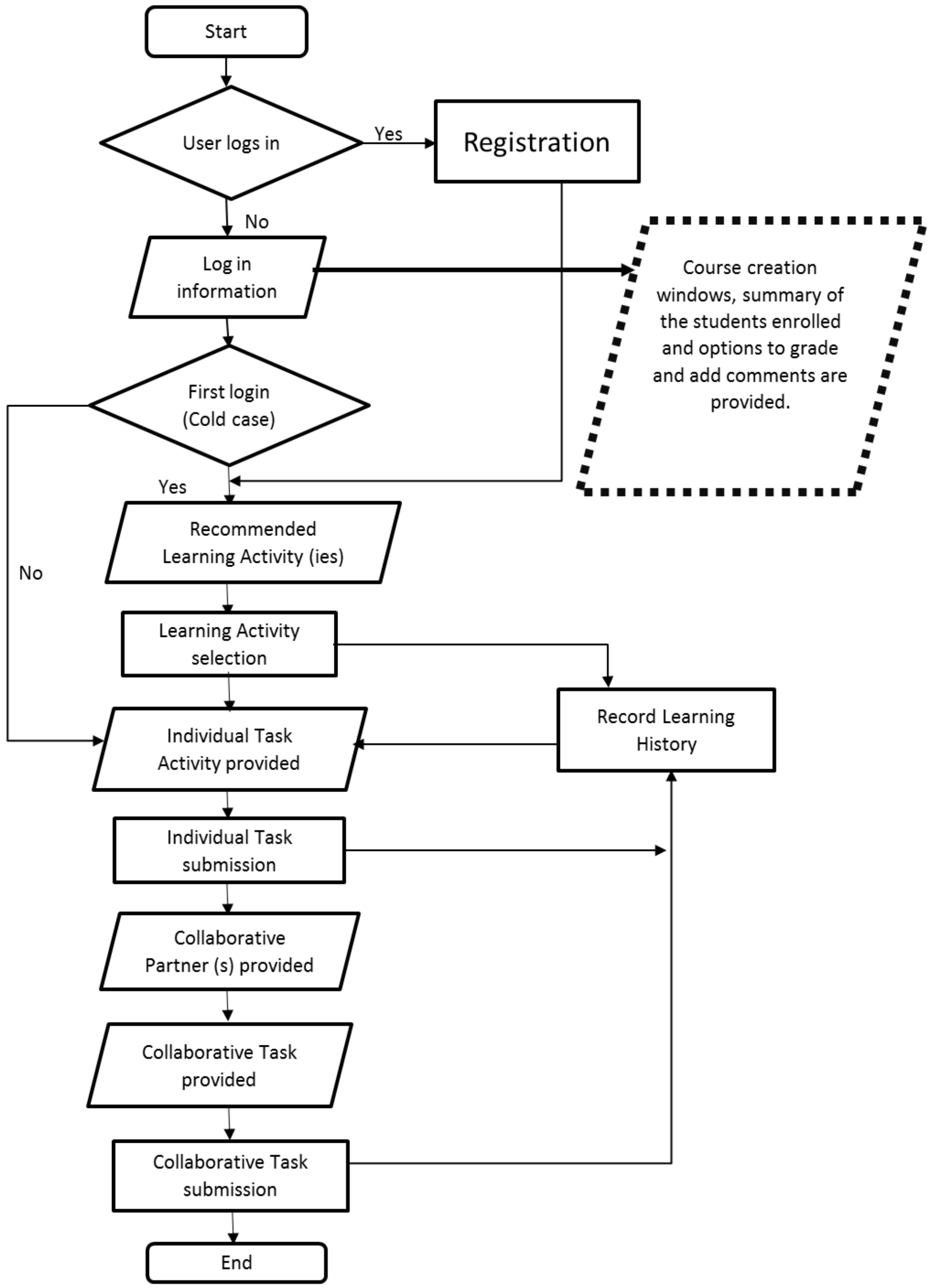

Figure 3.24: The system flow chart – on the learner's view

Figure 3.25 below summarizes the PECALE structure in terms of the activity flow and how rating was obtained in each step.

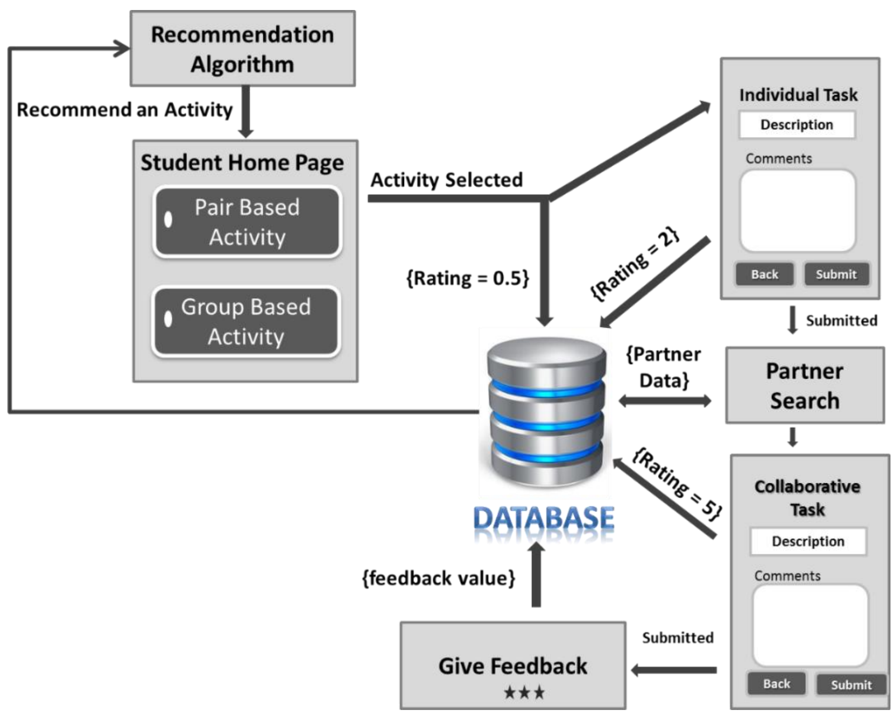

Figure 3.25: Activity workflow diagram

3.4 Summary

In this chapter, the guidelines that were used in the formulation of a context-aware learning environment pedagogical framework were discussed. They included ensuring sound educational practice, addressing the uniqueness of DL in the case of a DL environment, considering the context in which learning occurs and personalizing learning. The formulated CALE pedagogical framework that was built based on these guideline was presented. The chapter also discussed the approaches used to enhance personalization and enhance learner engagement. They included the utilization of learning preferences as context in which learning occurs. In particular, the learners' sociological preferences to learning and how it can be used as the basis for social personalization was discussed. The application of context-aware recommendation to involve learners through decision making was also reported. The use of structured small-group CL as an approach for enhancing learner engagement was also discussed. In particular, sociological preference similarity strategy as used in group formation and structuring the learning activity flow based on Kolb's Model were explained. The implementation of these approaches within CALE pedagogical framework resulting into PECALE software prototype was described. Finally, the chapter was concluded with a presentation of the PECALE architecture and its operation. The evaluation of PECALE is presented in the next chapter.

Chapter 4

4 The Evaluation of PECALE

This chapter presents the evaluation of PECALE. The chapter is organized in two sections. The first section presents the study's experimental set-up and the second section presents the results as well as the discussion of the results.

4.1 Experimental Set-up

This study required the use of multiple groups and multiple waves of measurements. The assignment was not explicitly controlled and the groups were not all similar to each other. Therefore, non-equivalent group Quasi-experimental design was used. This section explains in detail how the experiment was set-up including the test groups, the key areas that were measured and how the data was captured.

4.1.1 The Test Groups

The experiment was carried out on three different groups namely: Group 1 which comprised of intermediate level (B1&B2) German Language students at Goethe Institute Nairobi, Kenya; Group 2 which comprised of Masters (teacher- student) Didactics of Computer Science students, 'Sprintstudium' at Georg-August-University, Göttingen, Germany and Group 3 which comprised of second year Computer Science (CS) and Information and Technology (IT) students, in Systems Analysis & Design (SAD) course at

Kibabii University College, Kenya. These groups will be denoted as G1 to represent the intermediate level (B1&B2) German Language students, G2 to represent Masters (teacher-student) Didactics of Computer Science students, and G3 to represent the 2nd year CS and IT SAD as presented in Table 4.1. Three groups with different subject domains were chosen to give room for diversity in terms of subject domain and also determine if the approach used in PECALE cuts across different subject domains. This in turn reduced the selection threat.

Group	**Course**	**Level**	**Mode of learning**	**Initial No. of Students who Participated**	**Institution**
G1	German Language (GL)	B1 & B2	Online & Face to Face	20	Goethe Instit., Nairobi, Kenya
G2	Didactics of Computer Science (DCS)	Masters (teacher-student) Sprintstudium	Online	31	University of Göttingen, Germany
G3	Systems Analysis & Design (SAD)	2nd year Computer Science (CS) and Information & Technology (IT)	Online & Face to Face	85	Kibabii University College, Kenya

Table 4:1: Experimental groups

The reason as to why group G1 was picked was because of the ability of a language course to offer more interactive or conversational activities hence ideal for collaborative learning activities. Group G2 was chosen because this particular program employed blended learning approach. This gave an opportunity to test in an exclusively online learning scenario. The reason as to why group G3 was chosen was because the group comprised of on-campus students, therefore it was easier to carry out multiple tests with the same group. This made it convenient to carry out pre-test and post-test on the same group. The group size was also large enough to obtain reliable data. Furthermore, the nature of the course i.e. SAD gave an opportunity to offer collaborative and constructive activities which were ideal for this study.

4.1.2 Data Capturing Techniques

The data was captured through PECALE's behavior tracking mechanism, Canvas' discussion forum and feedback from the learners through the questionnaire. The PECALE's tracking mechanism was used to capture learners' actions like the learner's activity type selection, activity selection time, individual task submission time, collaborative task submission time and feedback on the activity. These actions were in turn used for preference rating and to measure the level of learner's participation and performance (explained in detail later). The design of the questionnaire was heavily influenced by the user experience questionnaire (UEQ) format. It was intended to capture explicit data from the learners' feedback. The questionnaire was used mainly to capture learners' level of satisfaction in using the study's approach, the learners' perception on using recommendation approach, and partly the learners' preference level.

4.1.3 Elements Measured and the Measuring Techniques

The experiment was set to observe and measure the learners' sociological preference in terms of pair or group preference; learners' participation; individual learners' performance; group performance and gauge learners' satisfaction. The following objectives were set to guide these measurements:

a) The first goal was to determine whether the argument that learners differ in individual needs (in this case- differ in sociological preference) is true. This was to be determined by observing learners' learning activity types (LAT) selection behavior and their preference levels.

b) The second goal was to determine whether this approach had any significance or impact in terms of:
    i. Learner engagement which was to be measured in terms of learner participation in both individual and collaborative tasks in the provided learning activities (LA)
    ii. Individual learner performance which was to be measured in terms of the time spent by an individual leaner on a LA
    iii. Group performance which was to be measured in terms of time a group spent on a LA

iv. Learner satisfaction which was to be measured based on the learner's response to relevant questions in the administered questionnaire.

v. Group cohesion which was not measured in this experiment but set for future work.

Determining Learners' Sociological Preferences and Preference Level

In this study the author argues that learners' sociological preferences differ. As a result, they need to be considered in order to provide a personalized learning experience. Since this argument was the foundation of this study, there was need to first proof or determine whether actually there exist diversity in learners' sociological preferences i.e. whether this argument is justifiable within PECALE platform. Though observing learners' LAT selection behavior could have been enough to determine whether learners differ in sociological preferences, however the author went a step further to establish learners' sociological preference by determining the extent to which individual learners are consistent in their preference of a LAT. The preference levels of the learners were also used to establish the differences in sociological preferences among learners. This was to be determined by measuring overall preference rating of each of the three test groups on the respective LAT.

Determining learners' sociological preference, consistence in preference and their preference level was determined using three techniques. They included the observation of the learner's LAT selection behavior, LAT rating and through learners' overall feedback captured through the questionnaire that was administered to them.

Learners' LAT Selection Behavior

The learners' LAT selection behavior were obtained through PECALE's tracking mechanisms which had been designed to record the specific actions in every LA. Every LA as earlier noted had three steps. The learner LAT preference was determined through the first step which was activity selection step. In the first step, two LAT i.e. one that required learners to work in pairs (pair-based) and one that required them to work in small-groups of 3 to 5 people (group-based) were presented to them. The learners were to choose based on their sociological preferences. In order to provide a fair presentation in terms of preference, three activities i.e. Activity1, Activity2 and Activity 3 (or Aufgabe 1, Aufgabe 2 and Aufgabe 3 as written in German language) were provided to each experimental groups i.e. G1, G2 and G3 as presented in Table 4.2. This technique was also used to determine whether learners differ in their sociological preferences based on LAT choice. It was also used to determine if the learners were consistent in their preferences based how they selected the LAT in the three LAs.

G1		G2		G3	
LA	**LAT**	**LA**	**LAT**	**LA**	**LAT**
Activity 1 (Aufgabe 1)	Group	**Activity 1 (Aufgabe1)**	Group	**Activity 1**	Group
	Pair		Pair		Pair
Activity 2 (Aufgabe 2)	Group	**Activity 2 (Aufgabe 2)**	Group	**Activity 2**	Group
	Pair		Pair		Pair
Activity 3 (Aufgabe 3)	Group	**Activity 3 (Aufgabe 3)**	Group	**Activity 3**	Group
	Pair		Pair		Pair

Table 4:2: Learning activities (LA) and Learning activity types (LAT)

Rating

This approach was used mainly to determine the learner's preference level of the two LAT (i.e. Pair-based (PB) and Group-based (GB)). The rating was determined as explained in *Section 3.3.3* and as presented in Table 4.3 as follows: first, the completion of each of the three steps in a LA added value towards the rating of a LAT. Then the learner was allowed to give their opinion about that particular activity through a feedback form that was provided after completion of all steps in the LA. The steps comprised of Activity selection (AS), Individual Task submission (ITS) and Collaborative Task submission (CTS). The CTS could either be a pair submission or group submission depending on the LAT the learner had selected. The rating after completion of every step contributed towards the respective LAT rating values.

The sum total of rating value for both pair based and group based activity was presented for all the three LAs. This made it possible to compare rating for both LAT for each learner, and acquire the minimum and maximum rating values for both LAT within every experimental group. It also made it possible to even determine the average preference rating value and the range in preference levels for both LAT in all the three groups.

		Rating Value	
		Minimum Value	**Maximum Value**
Steps Contributing to rating per student	Activity Selection (AS)	0 (for not selected)	0.5
	Individual Task Submission (ITS)	0 (for no submission)	1.5
	Collaborative Task Submission (CTS)	0 (for no submission)	2
	Feedback	-2	2
Total Rating per Activity (TRA)	Sum of rating for AS, ITS, CTS	0	6
Overall Rating Value	Sum of TRA for Activity 1, Activity 2 and Activity 3	0	18

Table 4:3: Actions for preference rating and rating values

Learners' Feedback

The last approach in determining learners' preference was through the feedback from the learners at the end of the experiment. The question was specifically directed to learners who had an experience working on both pair based and group based LAT. They were asked to rate their preferences on the two LAT as presented in *Q1* below. The five scale rating was used to determine the learners' level of preference on both the LAT. The highest value of 5 indicated strongly preferred and 1 for least preferred as shown in Table 4.4.

Q1. *Based on your experience working on the task (s) that require (s) you to work both with two persons and with more than two persons, how will you rate or compare your preference or liking of the tasks*

Working in pair (working in two)	Working in group (working with more than two persons)
☐ 5 ↑ Strongly preferred	☐ 5 ↑ Strongly preferred
☐ 4	☐ 4
☐ 3	☐ 3
☐ 2	☐ 2
☐ 1 ↓ Least preferred	☐ 1 ↓ Least preferred

Table 4:4: Preference level rating scale (questionnaire)

Measuring Engagement, Performance and Satisfaction

The next objective was to determine whether this approach had any significance or impact on the learners' engagement in term of participation; individual learners' performance; group performance, and learners' satisfaction. Therefore the measurement was carried out on these elements.

Learners' Participation

Learner's engagement was determined through observing the learner's behavior in terms of participating in the assigned LAs. Observing learner's behavior was made possible through activity design approach employed in PECALE. Every LA as already pointed out involved three steps and every test group had three LAs. The completion of the steps were key indicators of learner's participation in the learning process. A nine scale measurement was used to gauge the learner's level of participation with 9 indicating maximum and 1 indicating minimum participation as shown in Table 4.5.

Scale Value	**Steps**	**Indicator**
9	Completion of all three LAs	Maximum involvement
8	Completion of two LA and up to the 2^{nd} step in the 3^{rd} LA	
7	Completion of two LA and 1st step in 3^{rd} LA	
6	Completion of two LA	
5	Completion of one LA and up to the 2^{nd} step in the 2^{rd} LA	
4	Completion of one LA and 1st step in 2^{nd} LA	
3	Completion of one LA	
2	Completion of the 2^{nd} step in the 1^{st} LA	
1	Completion of the 1^{st} step in the 1^{st} LA	Minimum involvement

Table 4:5: Participation level rating scale

The participation of learners' on the normal Canvas discussion forum was also captured to provide a base for comparison on the level of learners' participation on a standard discussion forum and the study's small-group personalized approach. This comparisons was carried out only on G2 since the group's mode of learning was purely online. Since there was no face to face, the discussion forum was an ideal environment for the learners to interact. The data on the learners' participation in the discussion forums in comparison to PECALE's small-group participation was captured as shown in Table 4.6.

	Canvas Discussion forum Participation (%)	**PECALE Small-group Participation (%)**
Participated		
Active participants		
Topics		
Longest threat		

Table 4:6: Measuring learner participation on Canvas discussion forum

Lastly, the learners were also asked to gauge their participation using a five scale rating through a questionnaire as shown in Table 4.7.

Q2. By choosing my preferred form of collaboration (i.e. either to work in group or pair):

	Strongly Agree ⟵⟶ **Strongly Disagree**				
I was able to participate towards the task	**5**	**4**	**3**	**2**	**1**

Table 4:7: Participation rating scale (questionnaire)

Individual Learner's Performance and Group Performance

The next goal of the experiment was to determine whether considering learners' sociological preferences had any influence on the individual learner's performance and group performance. The aspect of time spent on a LA was used to measure both individual and group performance. This experiment was specifically administered to group G3 only. The reason as to why this group was selected for this specific experiment was because the experiment required to have two tests administered to the same subjects. This group's working schedule and environmental setting made it convenient to carry out a pre-test and post-test experiment on the same group under similar environmental condition. Another reason was because the group had the largest sample size among the three groups making it more suitable to acquire reliable data.

Two LA with similar strength in objectives but with different group composition mechanisms were given to the same group of students in a pretest and post-test experiments. Both learning activities were given in form of assignments that required the subjects to work in small-groups. For the pretest, Canvas LMS's grouping approach (Canvas GA) was used. Canvas uses either self-Sign-up (self-selection assignment) approach where students assign themselves groups or allows the teacher to assign the groups. In self-sign-up, the teacher can create sets of groups where students can sign up on their own. Students are still limited to being in only one group in the set, but this way students can organize themselves into groups instead of needing the teacher to do the work. The teacher can also require that all the group members be part of the same course section. Students can move themselves from one group to another, however, when students are done organizing themselves the teacher may want to disable self-sign-ups. In the second approach, the teacher structures the group in that students can be split into equal groups or the teacher assigns the groups manually. In this study, the second approach was used for the pretest whereby, through Canvas' grouping approach, the learners were split into equal groups of 5 students who were randomly selected. A total of 16 groups were formed however, 12 groups participated. The performance was measured in terms of the time the learners spend on the activity. The learner's individual performance was determined by capturing the time an individual accessed the LA to the time of the completion of the LA. For the group performance, the average start time i.e. the access time of every individual learner within the group to the time the group completed or submitted the task was determined.

For the post-test, PECALE's grouping approach (PECALE GA) was used on the same group of learners i.e. G3. However the number was reduced to 31 students who had participated in the pretest due to the internet connectivity challenge that arose during the experiment. This was because the 3 steps activity design in PECALE required internet connectivity for all the three steps. To reduce the testing threat and avoid pretest to affect how participants do on the post-test, the learners were given different tasks with equivalent objective strength. Both the pre-test and post-test platform were new to the users i.e. they were using each for the first time. Furthermore, only Activity 1 in PECALE was used in measuring the performance to avoid the effect that can be brought about by familiarity of the learners with the PECALE environment if Activity 2 and Activity 3 were to be used. Table 4.8 shows how data was captured on this particular test.

TE	**Group ID**	**Stud. ID**	**IST**	**Group ST**	**ACT**	**IP**	**GP**
Canvas GA	Group ID	Stud. ID	Activity Access time (AAT)	Mean AAT (MAAT) in group	Group Submission time (GST)	GST minus AAT	GST minus MAAT
PELACE GA	Group ID	Stud. ID	Activity Selection Time (AST)	Mean AST (MAST) in group	Collaborative Task Submission time (CTST)	CTST minus AST	CTST minus MAST

Key
TE – Testing Environment ; **IST** – Individual Start Time; **ACT**– Activity Completion Time; **IP** – Individual Performance; **GP** – Group performance

Table 4:8: Measuring performance (time) in Canvas GA and PECALE GA

Learners' Satisfaction

The learner satisfaction was captured through a questionnaire administered to the learners at the end of the testing. They were to rate their satisfaction and how they enjoyed working on the task on a five scale as shown in *Q3* and Table 4.9.

Q3. By choosing my preferred form of collaboration (i.e. either to work in group or pair):

	Strongly Agree ⟵⟶ **Strongly Disagree**				
	5	**4**	**3**	**2**	**1**
I was satisfied working with my collaborative partner(s)					
Enjoyed working on the tasks					

Table 4:9: Measuring learner satisfaction

The level of learner satisfaction was also captured qualitatively through open ended questions in the questionnaire. In the questionnaire, the learners were asked in their opinion to give the draw backs of working with PECALE and what they could suggest to be improved. Informal face to face interaction with some of the participant and comments in the discussion forums were also used to acquire data qualitatively.

Learners' satisfaction was also gauged by asking G3 who used both Canvas GA and PECALE GA to compare their liking of the two platform in terms of the allocation of collaborative partners as shown in *Q4* and Table 4.10 below.

Q4. After working with two collaborative learning platform i.e. one that allocates you a fixed number of collaborative partners like in SAD1 (i.e. Canvas GA) and one that offers options to choose on how you would like to work and assigns you collaborative partner(s) with similar preference like in SAD 2 (i.e. PECALE GA. How will you compare the two platforms?

SAD 1 (i.e. Canvas GA)		SAD 2 (i.e. PECALE GA)	
☐ 5	Strongly preferred	☐ 5	Strongly preferred
☐ 4		☐ 4	
☐ 3		☐ 3	
☐ 2		☐ 2	
☐ 1	Least preferred	☐ 1	Least preferred

Table 4:10: Comparison of Canvas GA and PECALE GA in preference

Effect of Recommendation

One of the approaches the study employed in order to enhance personalization and learner involvement was through use of recommendation mechanism as explained. Based on the learner's behavior like activity selection, individual task completion and collaborative task completion, rating value was determined on each LAT. An activity type with highest rating was recommended to the learner with the assumption that is the learner's most preferred type. However the learner had the power to decide on whether to pick the recommended activity type or pick another type. To determine whether the use of recommendation had any influence on the learner's decision in LAT selection, the students were asked the following questions:

Q5: Roughly, how often did you pick the recommended activity?

Q6: To what scale was the recommended activity in line with your level of preference in terms of the collaborative partners on each activity?

In *Q5*, a three scale rating was used and in *Q6*, a four scale rating was used as shown in Tables 4.11 and 4.12 respectively.

How often the learner picked recommended activity		
Throughout (i.e. 2 time)	Once (1 time)	Not at all (0 times)

Table 4:11: Assessing the influence of recommendation

To what scale the recommended activity was in line with the learner's level of preference			
Over 70%	Around 50%	Below 50%	0%

Table 4:12: Assessing the level at which the recommended activity was in line with learner's preference

4.2 Results and Discussion of Results

Based on the areas identified for measurement, the following are the results of the experiment and their discussion.

4.2.1 Learners' Sociological Preferences

In determining learners' preference, the results as recorded by PECALE's tracking mechanisms indicated differences in choices of LAT in all the three groups in all the three LA as depicted in Table 4.13. In the first LA, Activity 1, G1 had an even selection for both LAT with 10 students selecting PB and 10 selecting GB LAT. In G2, majority of the learners selected GB with only 6 selecting PB. G3 on the other hand had a higher number that selected PB as compared to GB for Activity 2. The results in terms of number of students selecting each LAT in every LA in all the three groups is presented in Table 4.13. The fact that different learners chose different LAT in all the groups, this confirms the study's argument that indeed learners' differ in sociological preferences.

LA	LAT	G1 (No. of Students)	G2 (No. of Students)	G3 (No. of Students)
Activity 1 (Aufgabe1)	Group-based (GB)	10	25	13
	Pair-based (PB)	10	6	18
Activity 2 (Aufgabe2)	Group-based (GB)	5	18	11
	Pair-based (PB)	8	12	11
Activity 3 (Aufgabe3)	Group-based (GB)	9	15	7
	Pair-based (PB)	4	8	11

Table 4:13: Learning activity type (LAT) selection

Consistence in Sociological Preferences of Learners

To determine whether actually there was a consistent in the learners' sociological preferences, the results as captured in Table 4.14 showed that out of around the 65%, 68% and 55% of students who participated in all the three LAs, in G1, G2 and G3 respectively, about 39%, 62% and 77% chose the same LAT in all the three LA in G1, G2 and G3 respectively. In G1 around 46% selected at least two PB LAT out of the three LAs with about 54% selecting GB LAT. In G2 and G3, around 38% and 65% selected at least two PB LAT respectively. While around 62% and 35% selected at least two GB LAT in G2 and G3 respectively. Based on the results, G2 and G3 learners showed some consistence in their preferences given the fact that a majority chose the same LAT.

	G1		**G2**		**G3**	
	No. of Stud.	%	No. of Stud.	%	No. of Stud.	%
No. of Participants	20	100	31	100	31	100
Completed all 3 LA	13	65	21	68	17	55
Selected same LAT in all 3 LA	5	39	13	62	13	77
Selected PB ≥ 2 times	6	46	8	38	11	65
Selected GB ≥ 2 times	7	54	13	62	6	35

Table 4:14: The trend in LAT Selection

Those who did not choose the same LAT, there was an inclination toward one LAT. For example G2 inclined toward GB and G3 inclined toward PB. G1 seemed not to indicate any consistence in their preference at the first glance, however, a further follow up from the results in Tables 4.15 and 4.16 revealed a slightly higher number having preference for PB as compared to GB. The learners' tendency to choose similar LAT on difference occasion showed consistence of these learners in their preference which confirmed these learners' sociological preferences. This further proved the study's argument that indeed learners have sociological preferences and these preferences defer among leaners.

Preference Level through Rating

As explained earlier, rating was used to determine the learners' sociological preferences level on a LAT. The results from LAT rating indicated the learners' diversity in terms of preferences as captured in Table 4.15. The rating value ranged from 0 points to a maximum of 17.8 points preference as revealed in the results. A 0 point value was an indicator that the LAT was not selected at all throughout the three LAs and a maximum of 18 point value was an indicator that the learner selected the particular LAT throughout the three LAs, completed all required steps in the three LA and gave positive feedback on the respective LAs. Among the three testing groups, G3 had on average the highest preference for PB LAT with an average rating value of 10.7. It also had the lowest GB LAT preference with an average value of 4.2.

	G1		G2		G3	
	Group LAT	**Pair LAT**	**Group LAT**	**Pair LAT**	**Group LAT**	**Pair LAT**
Min. Rating	0	0	0	0	0	0
Max. Rating	13.7	17.4	12.6	13.2	11.6	17.8
Aver. Rating	7.4	8.7	5.2	6.9	4.2	10.7

Table 4:15: Preference level per LAT per group

Learners' Feedback

The response from the learners who participated in both LAT, as obtained through the questionnaire also indicated mixed preferences from all the three groups as shown in Table 4.16. G2 and G1 had a noticeable percentage of learners that had the least preference for

GB LAT. G1 and G3 had the highest number that liked working in pair as compared to GB. Just to note that this feedback was only from students who had participated in both PB LAT and GB LAT and not those who had chosen the same LAT throughout. Most importantly the results showed different preferences in all the groups, an indicator that indeed learners' sociological preferences differ hence once again agreeing with the study's argument.

Group	Activity Type (AT)	Strongly Preferred ←				→ Least Preferred
		5	**4**	**3**	**2**	**1**
G1	Working in pair (PB)	47%	27%	27%	0%	0%
	Working in group (GB)	36%	36%	21%	0%	7%
G2	Working in pair (PB)	21%	47%	21%	11%	0%
	Working in group (GB)	5%	5%	37%	42%	11%
G3	Working in pair (PB)	63%	33%	4%	0%	0%
	Working in group (GB)	52%	33%	15%	0%	0%

Table 4:16: Comparison of preference for learners who participated in both LATs

In summary, students choosing different LAT with attendance of choosing similar type on difference occasion is proof that learners have sociological preferences and the preferences defer among leaners. This was confirmed by direct feedback from the learners as captured in Table 4.16. These results supports the study's initial argument that learners exhibit difference sociological preferences to learning. Therefore, sociological preferences of individual leaners need to be considered to achieve social personalization and formation of effective learning groups.

4.2.2 Learner Engagement

PECALE tool was designed with the intention of maximizing learner engagement in the learning process. This was measured through learners' participation in the assigned LAs. Every LA had 3 steps as already explained. Every step ensured or required learner participation. The very fact that a learner could choose an LAT in the very first step i.e. Activity Selection (AS) step already involved the learner. The use of recommendation system was to give the learner's opportunity to still make their own choice in AS process instead of having the system adapt to their needs without their involvement as it is the case with adaptation techniques. The other steps that determined the learner participation as pointed earlier were their involvement in both individual and collaborative tasks. This was captured through the Individual task submission (ITS) and Collaborative task submission (CTS) actions. On determining learners' participation, the results as presented in Table 4.17 and the graph in Figure 4.1 showed the participation level to be significantly high especially in the first LA (Activity 1) where all learners i.e. 100% successfully completed all the three steps in G1 and G2 with G3 recording about 97%. For the students who proceeded to the second LA (Activity 2), still a significant number was able to complete all the three steps with G2 recording the highest percentage of 71% of students who successfully completed step 3 (i.e. CTS). However G2 recorded the lowest percentage in the completion of last LA (Activity 3) with around 45% successfully completing all the three steps.

The following factors could have been attributed to this drop in participation in G2. One factor that could have contributed was the lack of a deadline. The author had set deadlines for completion of LA 1 and 2. Since it was the last LA, the author's assumption was that the students will by default work with the overall scheduled time for the test which was a 5 days period. However this might have led to relaxation among the learners. A noticeable increase in participation was recorded after setting the deadline. However it was only four hours to the end of the scheduled session so this could not cause much difference.

Technical and communication challenges could also have been one of the main contributors to this dropout as discovered later through the feedback from the learners. One of the major challenge pointed out by the participants was difficulty in communicating or linking up with their group members especially with those who picked group-based activity.

Another factor could have been attributed to the closeness to the beginning of the face to face session - 'Sprintstudium'. The testing was to run till the weekend to the beginning of the 'Sprintstudium' with last LA expected to be submitted the Friday to this weekend. Since G2 as mentioned earlier were teachers, they already have limited time and they needed to prepare for the beginning of the course and absence from their work place. This could have been overwhelming for them especially to get a partner or group that was available or free to work within the same time schedule. This information was noted after informally interacting with some of the participants during their face to face session – i.e. the "sprintstudium" session.

Though G1 and G3 had a fairly consistent participation rate in all the three activities, however, the drop in the number of participants in Activity 2 and 3 compared to Activity 1 could have been attributed mainly to the technical challenge and time limitation. The experiment with G1 and G3 was carried out during normal class time as a located to respective courses used in the study. Therefore, the learners were supposed to complete this activities within this time.

		No. of Students Completing every Step in each Group								
		G1			**G2**			**G3**		
Activity	**Steps**	**AS**	**ITS**	**CTS**	**AS**	**ITS**	**CTS**	**AS**	**ITS**	**CTS**
Activity 1	No. Completed	20	20	20	31	31	31	31	31	30
	% of Total No.	100	100	100	100	100	100	100	100	97
Activity 2	No. Completed	13	12	12	30	25	22	22	21	20
	% of Total No.	65	60	60	97	81	71	71	68	65
Activity 3	No. Completed	13	13	13	23	17	14	18	18	18
	% of Total No.	65	65	65	74	55	45	58	58	58

Table 4:17: Learner participation in terms of completion of LA steps in all the three LAs

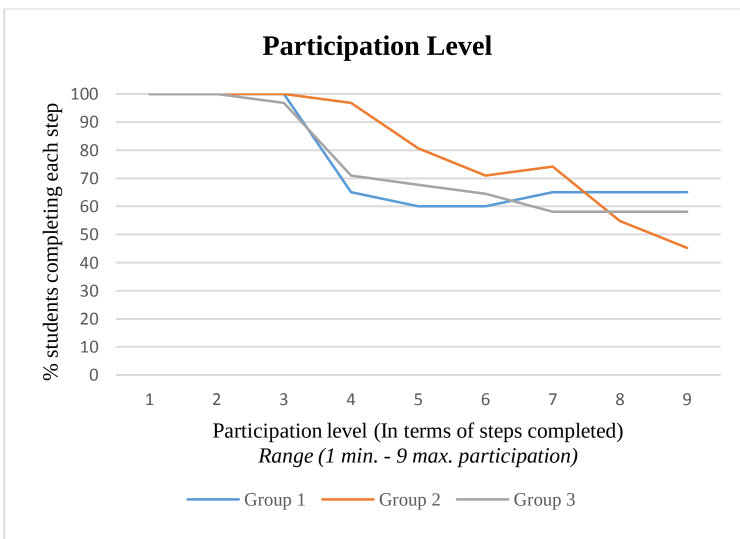

Figure 4.1: Learner participation in terms of completion of LA steps in all the three LA for the three groups.

The graph in Figure 4.1 depicts the participation level based on a 9 scale rating as presented in Figure 4.5. A 9 value indicates maximum participation in that the learners participated in all steps in all the LAs provided in the three groups. While a 1 value indicates that at least the learners participated in the first step of the first LA. This was the minimum participation. The graph in Figure 4.1 is a reflection of the results in Table 4.17.

Comparing the participation on the Canvas discussion forum with participation in PECALE, there was a significant difference as shown in Table 4.18. This comparison was only made on G2 group since it was the only group that worked exclusively online. Active participation in PECALE was measured in terms of the students who were able to participate in or completed all steps in all the three LAs. While in Canvas discussion forum, active participated was assessed based on how much the learner had contributed or participated in all topics in the discussion forum. The results showed that only 29% of the 31 students participated in the discussion forum in the entire five day period with only 10% actively participating as compared to 46% in PECALE. Six topics were discussed in the discussion forums focusing majorly on system usability or technical issues with the longest threat being 18.

	Canvas Discussion forum Participation	PECALE Small-group Participation
Participated	29%	100%
Active participants	10%	46%
Topics	6	3 LAs
Longest threat	18	

Table 4:18: Comparison of learner participation in in Canvas discussion forum and PECALE

A positive feedback was also received from the learners on participation when using the study's approach. Asked to rate their participation towards the tasks that were provided, slightly over 80% of the 65 students who responded to this question gave a rating of 4 and 5 out of a scale of 5 as shown in Table 4.19.

I was able to fully participate towards the task						
Group	**No. of Respondents**	**Strongly Agree**				**Strongly Disagree**
		5	**4**	**3**	**2**	**1**
G1	13	8	5	0	0	0
G2	25	3	11	4	6	1
G3	27	19	7	1	0	0
Total (G1, G2 & G3)	**65**	**30**	**23**	**5**	**6**	**1**
	100%	**46%**	**35%**	**8%**	**9%**	**2%**

Table 4:19: Learner feedback on participation

4.2.3 Individual Learner's Performance and Group Performance

In order to ascertain whether the study's approach was effective, a paired t-Test was performed to compare individual and group performance when using Canvas GA and when using PECALE GA. A paired t-Test was used because the study needed to make a comparison of two different treatments applied to the same subjects. The treatments i.e. use of Canvas GA and use of PECALE GA were applied on G3 only. Only one LA (i.e. Activity 1) was used in PECALE as explained earlier in the experimental set-up section. The performance was measured in terms of time as follows:

Determining Mean Individual Performance

The individual performance for each student was measured in terms of the time taken by each student to complete the LA when using both Canvas GA and PECALE GA as shown in equation *4.1* below.

$$Individual\ Performance\ (IP) = Completion\ Time\ (CT) - Start\ Time\ (ST) \tag{4.1}$$

Where:

- Completion Time (CT) – Stands for the time LA is completed – i.e. the time when a collaborative task was submitted
- Start Time (ST) – stand for start time – i.e. the time an individual started to work on an activity (in PECALE it was determined by activity selection time (AST) while in Canvas it was determined by the time an individual accessed the activity i.e. activity access time (AAT))

The average individual performance when using both platforms was then determined as shown in equation *4.2*.

$$Mean\ Individual\ Performance\ (MIP) = \frac{Total\ IP}{No.of\ students}$$

(4.2)

Determining Mean Group Performance

To measure group performance, first, the average start time for all members in each group was calculated to determine the group start time as shown in equation *4.3.* The second step was to determine group performance for each group as shown in equation *4.4.* The average group performance for all the groups was then determined as shown in equation *4.5*.

$$Group\ Start\ Time\ (GST) = \frac{Total\ ST}{No.of\ group\ members}$$

$$= Average\ group\ members\ ST$$

(4.3)

$$Group\ Performance\ (GP) = Completion\ Time\ (CT) - Group\ Start\ Time\ (GST) \tag{4.4}$$

$$Mean\ Group\ Performance\ (MGP) = \frac{Total\ GP}{Total\ No.of\ groups} \tag{4.5}$$

Comparing the Performance in Canvas GA and PECALE GA

The results were then compared using t-Test to determine the difference in group and individual performance for both platforms. The alpha level for the t-Test was set at a level of 0.05 which is the recommended level for most social research.

The hypotheses for the comparison of the means in this setting was as follows:

H_0: $\mu_1 = \mu_2$ (the means of the two grouping approaches i.e. Canvas GA denoted as (μ_1) and PECALE GA denoted as (μ_2) are the same).

This was tested against the alternative:

H_a: $\mu_1 \neq \mu_2$ (the means of the two approaches are different).

To determine whether there was evidence that PECALE's GA enhanced individual performance in terms of time spent on a LA as compared to using Canvas' GA, the difference (d_i) was calculated as follows:

$d_i = \mu_{1i}$ "mean of Canvas GA MIP" - μ_{2i} "mean of PECALE GA MIP"

The hypothesis tested was:

H_0: $\mu_{di} = 0$ (the mean of the differences is zero; i.e., PECALE's approach was ineffective on individual learner's performance).

Which was tested against the alternative:

H_a: $\mu_{di} > 0$ (the mean of the differences is positive; i.e., PECALE's approach was effective on individual learner's performance).

To determine whether PECALE's GA enhanced group performance in terms of time spent on a LA as compared to using Canvas' GA, the differences (d_g) was calculated as follows:

$d_g = \mu_{1g}$ "mean of Canvas GA MGP" - μ_{2g} "mean of PECALE GM MGP"

The hypotheses tested was:

H_0: $\mu_{dg} = 0$ (the mean of the differences is zero; i.e., PECALE's approach was ineffective).

Which was tested against the alternative:

H_a: $\mu_{dg} > 0$ (the mean of the differences is positive; i.e., PECALE's approach was effective).

The results of the t-Test for individual performance and for group performance are as shown in Table 4.20. On individual performance, the results indicated that when using Canvas' GA on average, every students spend around 52 minutes. With the same group of students, when using PECALE GA, every student used on average 28 minutes to complete the assigned LA. On group performance every group spend around 52 minutes on average to complete the assigned learning activity when using Canvas GA and the groups spend on average around 29 minutes when using PECALE's GA.

	t-Test: Paired Two Sample for Means Individual Performance		t-Test: Paired Two Sample for Means Group Performance	
	Variable 1	***Variable 2***	***Variable 1***	***Variable 2***
Mean	52	27.6	51.5	28.6
Variance	236	230.7237	238.4545	210.0242
Observations	30	30	12	12
Pearson Correlation	-0.16182		-0.39268	
Hypothesized Mean Difference	0		0	
df	29		11	
t Stat	5.73405		3.181848	
P(T<=t) one-tail	1.66E-06		0.004366	
t Critical one-tail	1.699127		1.795885	
P(T<=t) two-tail	3.31E-06		0.008732	
t Critical two-tail	2.04523		2.200985	

Table 4:20: Comparison of Individual performance and group performance between Canvas GA and PECALE GA

Looking at the output on individual performance in Table 4.20, the calculated t-statistic (with 29 df) is given by 5.73405, which has a p-value of 3.31E-06 and t Critical two-tail of 1.669127. Since t-Statistic > t Critical two-tail, and the mean of the μ_{1i} minus μ_{2i} differences is positive, this is supportive of the alternative hypothesis that $\mu_{di} > 0$. A proof that PECALE's GA had a positive impact on individual learner's performance. The approach enhanced individual learner's performance in terms of reduction on time spent on a learning activity as compared to using Canvas' GA.

For the output on group performance, the calculated t-statistic (with 11 df) is given by 3.181848 with a two-tail p-value of 0.008732 and t Critical two-tail value of 2.200985 as shown in Table 4.20. The results also revealed that t Statistic > t Critical two-tail, and the mean of the μ_{1g} minus μ_{2g} differences is positive hence supportive of the alternative hypothesis that $\mu_{dg} > 0$. Therefore, there is evidence that PECALE's GA also had a positive impact on groups' performance in that the groups spent less time on a collaborative activity as compared to time they spent on an activity of similar strength with Canvas GA.

Therefore the study's approaches which included the consideration of learners' sociological preferences in small-group formation enhances both individual learner's and group's performance as shown by the results obtained from the t-Test.

4.2.4 Learners' Satisfaction

The significance of the study's approach was also measured through gauging the learners' level of satisfaction. In general, with all the three groups combined, a positive feedback was received with around 76% expressing their satisfaction working on the LAT they picked with a 4 and 5 out of 5 rating scale as shown in Table 4.21 and Figure 4.2. Still with all groups combined, around 62% agreed to have enjoyed working on the task with 66% giving the highest rating of 4 and 5. Around 81% rated 4 and 5 for being able to participate towards the task as captured in Table 4.21.

By choosing preferred form of collaboration (i.e. either to work in group or pair)							
		No. of Respondents	Strongly Agree ⟷ Strongly Disagree				
			5	**4**	**3**	**2**	**1**
was satisfied working with my collaborative partner(s)	G1	14	64%	36%	0%	0%	0%
	G2	26	4%	39%	27%	31%	0%
	G3	27	56%	41%	4%	0%	0%
Total (G1, G2, & G3)	**G1,G2 & G3**	**67**	**37%**	**39%**	**12%**	**12%**	**0%**
was able to participate towards the task	G1	13	62%	39%	0%	0%	0%
	G2	25	12%	44%	16%	24%	4%
	G3	27	70%	26%	4%	0%	0%
Total (G1, G2, & G3)	**G1,G2 & G3**	**65**	**46%**	**35%**	**8%**	**9%**	**2%**
Enjoyed working on the tasks	G1	13	62%	31%	8%	0%	0%
	G2	26	0%	27%	46%	23%	4%
	G3	26	69%	23%	4%	4%	0%
Total (G1, G2, & G3)	**G1,G2 & G3**	**65%**	**40%**	**26%**	**22%**	**11%**	**2%**

Table 4:21: Learner feedback on satisfaction (including participation and enjoying working on the tasks

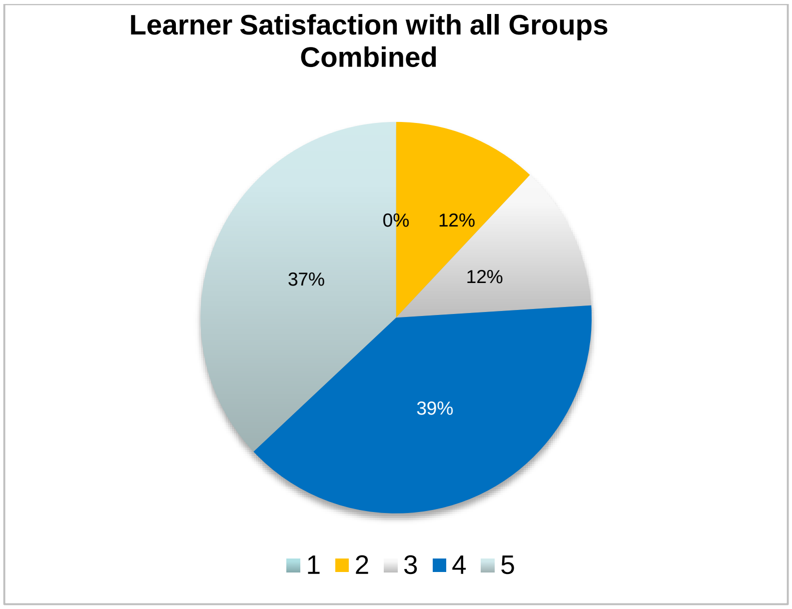

Figure 4.2: Learner feedback on satisfaction

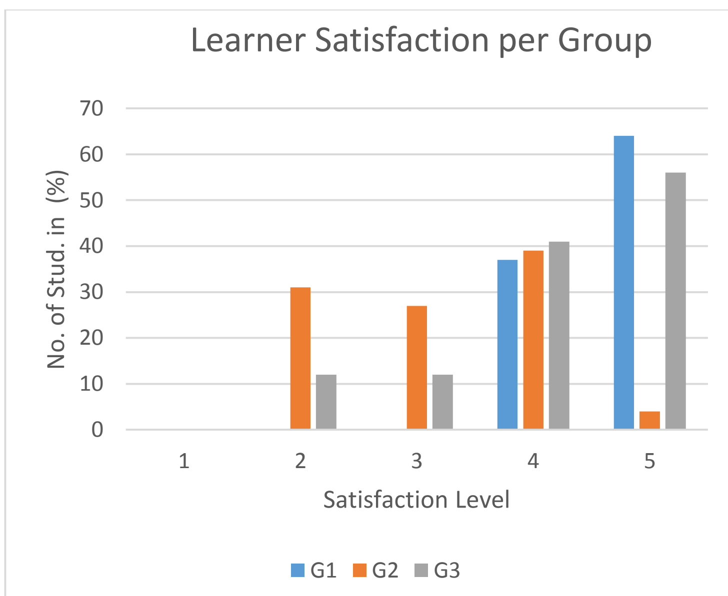

Figure 4.3: Learner feedback on satisfaction per group

However, among the three groups, group G2 registered the lowest rating especially on satisfaction and enjoying working on the tasks as shown in Table 4.21 and Figure 4.3. This could have been attributed largely to the fact that G2 worked entirely online as compared to G1 and G3 which interacted face to face during the actual working on the collaborative activities.

Technical and communication challenges were also the main contributors to dissatisfaction among the G2 participants as discovered through the feedback received from them. This was captured qualitatively through open ended questions in the questionnaire, through informal face to face interaction with some of the participant and through comments in the discussion forums. The most common challenge pointed out was the difficulty in interacting with collaborative partners. The learners had only been provided with their partners or group members' email addresses. They were then expected to use the existing means of communications like skype, email, Facebook that was convenient for them. One of the reasons as to why this approach was used was because the researcher did not want to limit the learners on how to communicate.

Furthermore, the development of an advanced interactive platform was not within the researcher's scope of research. Furthermore, since the course they were to prepare for the "Sprintstudium" was on number system, it was time consuming to type and conveniently discuss through email with collaborative partners especially in group-based activities. The summary of the response to the questions are presented in Table 4.21 and the graph in Figure 4.2.

4.2.5 Overall View in Terms of Collaborative Partner(s) Allocation

Still on learners' satisfaction, group G3 which had used both Canvas GA and PECALE's GA was asked to compare their liking of these two approach in terms of the assignment of collaborative partners. The feedback from the learners showed significant preference to PECALE's approach with slightly above 82% having a strong preference for PECALE's GA as compared to about 44% for Canvas GA as revealed in Table 4.22 and Figure 4.3.

Liking in terms of collaborative partner(s) assignment			
	Rating Value	Platforms	
Strongly preferred		Canvas GA (%)	PECALE GA (%)
	5	44	82
	4	39	11
	3	13	7
	2	4	0
Least Preferred	1	0	0

Table 4:22: Comparison between Canvas CA and PECALE GA in terms of learner liking

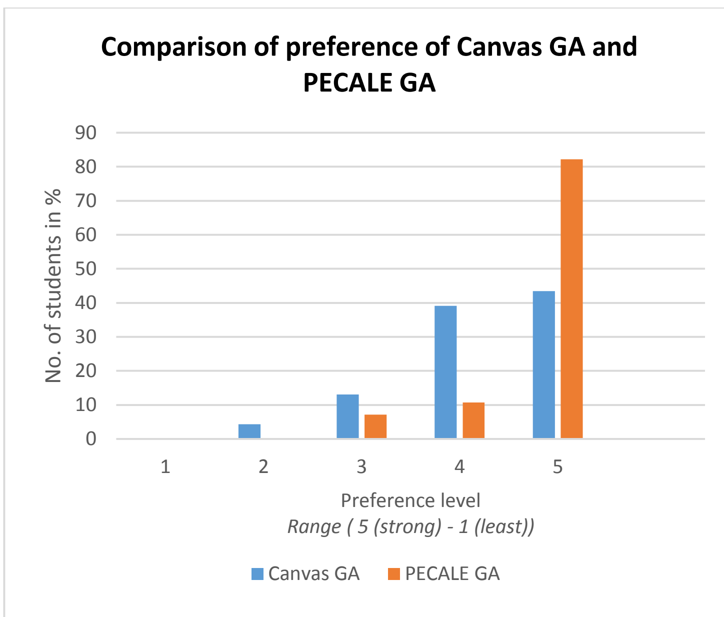

Figure 4.4: Comparison between Canvas CA and PECALE GA in terms of learner liking or preference

4.2.6 Effect of Recommendation

The last goal was to find out if the use of recommendation had any effect on the learners' decision in LAT selection. On how often the learners picked recommended activity, around 91% of all the three groups said they picked a recommended activity at least once as shown in Table 4.23. Around 36% of all the three groups combined were of the view that the recommended activity was over 70% in line with their level of preference. A slight majority i.e. around 56% said that the recommended LAT was around 50% in line with their level of preference as indicated in Table 4.24.

How often the learner picked recommended activity				
Group	***Respondents***	***Throughout (i.e. 2 time) (%)***	***Once (1 time) (%)***	***Not a tall (0 times) (%)***
G1	12	50	50	0
G2	25	40	40	20
G3	28	61	36	3
Total	**65**	**51**	**40**	**9**

Table 4:23: How the learners picked the recommended activity

To what scale the recommended activity was in line with the learner's level of preference					
Group	***Respondents***	***Over 70% (%)***	***Around 50% (%)***	***Below 50% (%)***	***0% (%)***
G1	11	45	45	10	0
G2	22	23	59	14	4
G3	28	43	57	0	0
Total	**61**	**36**	**56**	**7**	**1**

Table 4:24: How the recommended activity was in line with learner's preference level

Based on the results, it was not clear enough as to whether the LAT recommendation played a significant role in influencing the learners' decision or it was purely the preference of the learner. Asked the reason as to why they picked the particular LAT, the most popular reason given by the learners was because the LAT was in line with their preferred way of working. This response from the learners was captured qualitatively through an open question that asked the learners to state the reason as to why they picked a particular LAT.

Though the influence of recommendation on learners' LAT selection was not clear, however, it was clear that with the use of recommendation, the learner had the power to decide on whether to select the recommended activity type or pick another type. This in turn provided the learner a platform to be involved by making their own decision instead of having the activity be adapted to their situation without their involvement.

4.2.7 Challenges

Though the evaluation of PECALE was successful, however, there were some challenges that were encountered when carrying out the experiment. Though this challenges did not influence the outcome of the experiment, however, they posed some constrains in the carrying out of the experiment. The challenges originated mainly from the nature of the test groups used, the timing, technical constrains, organizational aspect, the coordination with teachers and work load.

Nature of the Test Groups

As noted earlier, the experiment was carried out on three groups. G1 comprised of intermediate level (B1&B2) German Language students at Goethe Institute Nairobi, Kenya; G2 comprised of Masters (teacher- student) Didactics of Computer Science students, Sprintstudium, University of Goettingen, Germany and G3 comprised of second year Computer Science (CS) and Information and Technology (IT) students, at Kibabii University College, Kenya. These groups had their own uniqueness. For example G2 who are in essence adult working learners, given their busy schedule, time was of fundamental importance. Furthermore, the native language for this group was German language and the experiment was entirely carried out online with this group (i.e. there was no face to face session). Given the fact that the researcher and the technical support team were all not German native speakers, language was one of the major constrain. As a result, more time was required to address technical question asked in German language and /or answer in German. Furthermore, since the technical team were also students, they were busy with examinations during the experimentation period. Therefore the researcher had to coordinate the entire process including responding to questions. Given that the group was around 30 students, this was strenuous to the researcher. Furthermore, delays in terms of feedback caused frustrations among the participants.

G1 on the other hand comprised of mainly young students who hand just completed high school. By the time the experiment begun the high school results had been released. This resulted into slight drop in the number of the participants as earlier expected. However the sample size was still sufficient for the experiment. Furthermore, group G3 boosted the sample size for the group applying both online learning and face to face mode of learning.

The Timing of the Experiment

The period the experiment was carried out was a major challenge to all groups. For G1 and G3, it was just close to examination time. As a result, some student were reluctant to take part in the study but never the less, a significant number volunteered to take part as shown by the number in the results section. For G2, the experiment was carried out very close to the beginning of "Sprintstudium" session. The test was to run till the weekend to the beginning of the session. Though the tasks given in the experiment were in preparation for the program, however, since the G2 as mentioned earlier were teachers, they needed also to prepare for the beginning of the course and absence from their work place. This could have been overwhelming for them as was reflected in the participation level in the last LA.

Technical Constrains

Technical and communication limitations were a major drawback in the study. They were mainly as a result of usability issues and internet connectivity. One of the major challenge pointed out by the G2 participants was difficulty in communicating with their collaborative partners due to the limited interactivity with PECALE platform. Since the experiment was to be entirely online, this made it difficult and time consuming to type and conveniently discuss. This also resulted into dissatisfaction among some participants. G1 and G3 hand a major challenge with internet connectivity. This also led the researcher to reduce group G3 participants from 65 to 31 in order to acquire faster and reliable internet connection.

Organization Aspect

In all the three groups, the LAs were designed within the respective course schedule. For G1 & G3 the experiment was to be carried out during the normal a located class time for the respective courses. For G2, it was scheduled within the normal Sprintstuduim preparation routine. Therefore time was restricted in all the groups. This led the researcher to work with the minimum requirement for this experiment in terms of LA which was three LAs.

Coordinating with Teachers

Coordination with teachers posed another challenge. It was difficult to bring the busy teachers on board when designing the LAs. However, the researcher's prior experience in teaching and curriculum design came in handy in several occasions.

Work Load

Working with three groups ranging from 20-65 students from different institutions was challenging for one person to manage. Therefore in future, assistants may be required to effectively management such type of experiment.

4.3 Summary

This chapter described how PECALE was evaluated. A detailed explanation on the experimental set-up including the key elements that were assessed was presented. The result from the experiment proved that learners have sociological preferences and these preferences differ from learner to learner. The results also showed that considering learners' sociological preferences in assigning collaborative members has a positive impact on learners' performance at both individual level and group level. The results also revealed commendable participation from learners in the given learning activities. However the experimental process was also faced with some challenges which are reported in this chapter.

Chapter 5

5 Conclusion and Outlook

As transformation arises in educational set-up as a result of the application of context-aware technologies, so has the challenges emerged. One of the challenge is how to apply sound pedagogical foundation when employing these technologies. Furthermore, although the adaptation approach as used by Context-aware systems has the potential to tailor learning to learners' needs, how to offer a learning experience that caters for the needs of each learner in an extremely diverse environment has been a challenging task. Moreover, the notion of adaptation as used in context-aware technologies has raised concerns over its inability to engage learners in the learning process. This concluding chapter summarizes the study's approach in addressing these challenges as its contributions. A summary of the results and an outlook on the future work are also presented.

5.1 Main Contributions

This research work was aimed at achieving five main goals. The first goal was to formulate a framework to offer a platform for the integration of pedagogy and technology in a CALE. This goal was aimed at addressing the challenge of applying sound pedagogical foundation when utilizing context-aware technologies in learning environment. The end result in achieving this goal was the formulation of CALE pedagogical framework. The framework provides a guideline on how best CALE can be rooted in sound pedagogical practices.

The second goal was to enhance personalization through exploration of internal context. The nation of personalization was examined in this study in attempt to address the diversity challenge while allowing learners to be involved in the learning process. To achieve this goal, the study considered leaning preferences as context in order to provide conditions that optimize learning for each learner. This approach was also intended to address diverse individual learner needs hence attain personalized learning. Since personalization is in essence a broad area, in order to explore in depth the study's approaches to enhancing personalization, the scope of personalization in this study was limited to social personalization. In particular, leaners' sociological preferences were considered as a basis for social personalization.

The third goal was to enhance learner engagement at both individual and in a collaborative environment. This goal was aimed at addressing the learner engagement challenge - a challenge resulting from the adaptation approach utilized by context-aware technologies which limits learner involvement. In order to engage learners at the individual level, context-aware recommendation approach was explored with the aim of involving learners through decision making. To enhance learner engagement in a collaborative environment, social personalization and small-group collaborative learning approach were explored. Specifically, sociological preference similarity strategy was used as a basis for group formation. This strategy was targeted at enhancing leaner engagement and performance within the groups. Another strategy used was structuring the learning activity flow based on Kolb's experiential learning model with an extension on the active experimentation phase. This approach was intended to ensure learner involvement at both individual and collaborative level.

The fourth goal was to implement a personalized and engaging context-aware learning environment (PECALE). Based on the CALE pedagogical framework, the proposed approaches to enhancing personalization and learner engagement were used as a guideline in the development of PECALE software prototype.

Lastly, PECALE was evaluated. An experiment was carried out on three different groups of students from three different institutions of higher learning. The results proved that indeed learner's learning preferences (in this case sociological preferences) differ. Hence the study's argument that consideration of learners' learning preference is an important key for reaching diverse individual learner needs is valid. Therefore, it should be considered in providing personalized learning. The results also proved that the study's approach had positive impact on learner engagement in terms of learner participation, individual performance and group performance. Generally, learners preferred the study's approach in terms of how the groups were formed. A majority were satisfied with the study's approach in overall.

5.2 Outlook

The contributions of this thesis lay a foundation for further research in this area. In particular, interesting observations were made that probably need to be considered in future work. For example the reoccurrence of similar group members in the same group for different learning activities. This was particularly observed in the G2 group that worked purely online. In this group, at least two to three members were retained in the same group in activity two and three. This was observed especially among "early beginners" (i.e. those who were usually the first to work on the provided tasks) and "late beginners" (i.e. those who were usually among the last ones to begin or work on the tasks provided). This could be an indicator of a relation between the learners' working pace, preferred working time span, and social preference. It will be interesting to find out if the consideration of these dimensions could further enhance group performance. It will also be interesting to extend the contextual dimension to include external contexts to determine their influence on group formation and performance.

Since system usability was one of the main drawback of PECALE, therefore for effective usability of PECALE, an advanced interactive platform should be developed or PECALE should be integrated with an already existing platform that supports maximum interaction among participants. Furthermore, in future work, it will be recommended to provide more learning activities in establishing relative preference and consistence in preference.

On a different note, it has been argued that members of strongly cohesive groups are more inclined to participate readily and to stay within the group. In a typical on-campus setting, formation of cohesive learning groups is easily achievable. However this may not be the case in a virtual learning environment. Therefore it may be interesting to explore more the fields of social psychology, collaborative learning and machine learning. Particularly it will be interesting to examine the connection of similarity strategy theory and clustering approach in an attempt to establish strong group cohesiveness in learning groups.

Further investigation on cognitive domain as an extension to this work will also be interesting. From a pedagogical perspective, the importance of cognitive domains like emotions and affect on learning have been explored. Especially the relationship between emotions and affective learning has been established. However, its extension and utilization in TEL is still in its infancy. Cognitive domain in itself is a cross-disciplinary, touching aspects of computer vision, robotics, artificial intelligence (AI), machine learning and psychology. The recent years, has seen increasing efforts from AI communities to research and design Artificial cognitive systems that can perform outside of closely controlled lab environments into complex and real-world situations through context-awareness. The application of the findings of such researches in TEL may be interesting since a typical learning scenario happens in a natural setting rather than a controlled lab.

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List of Figures

List of Tables

List of Abbreviations

DL	-	Distance Learning
CALE	-	Context-aware Learning Environment
CL	-	Collaborative Learning
	-	
COI	-	community of inquiry
GB	-	Group-based
LA	-	Learning Activity
LAT	-	Learning Activity Type
TEL	-	Technology Enhanced Learning
PB	-	Pair-based
PECALE	-	Personalized and Engaging Context-aware Learning Environment
PPF	-	Park’s Pedagogical Framework

Author's Publications

1. B. Mayeku, S. Edelev, S. Prasad, H. Karnal, D. Hogrefe. PECALE: An Environment for Enhancing Personalization and Learner Engagement in an Online Learning Platform. IEEE International Conference on Advanced Learning Technologies (ICALT), Hualien, Taiwan, July, 2015
2. B. Mayeku. Enhancing Personalization and Learner Engagement through Context - aware Recommendation in TEL. In The ACM Conference Series on Recommender Systems (RECSYS'14), Silicon Valley, USA, October 2014
3. B. Mayeku and D. Hogrefe. Towards a Conceptual Framework for Integrating Pedagogy & Technology in Adaptive Pervasive DL Environment. . In E-Learn - World Conference on E-Learning, Las Vegas, USA, October 2013.
4. B. Mayeku, D. Hogrefe and E. Modrow. Could Adaptive Context-aware Pervasive Learning Environment be a Possible Solution to Quality Higher Education and Learner Retention in DL? In eLearning Innovations Conference (eLi), Nairobi, Kenya, July 2013.

Questionnaire

The questionnaire that was administered to collect the overall feedback from the students. The first section of the questionnaire was used mainly to collective quantitative type of data. However, it had some few sections that were used to capture the qualitative type of data.

(This question was given to G3 only)

Q1. After working with two collaborative learning platform i.e. one that allocates you a fixed number of collaborative partners like in SAD1 (i.e. Canvas GA) and one that offers options to choose on how you would like to work and assigns you collaborative partner(s) with similar preference like in SAD 2 (i.e. PECALE GA. How will you compare the two platforms?

	Strongly preferred ⟷			**Least preferred**
	5	**4**	**3**	**2**	**1**
Working with SAD 1 (i.e. Canvas GA)	☐	☐	☐	☐	☐
Working with SAD 2 (i.e. PECALE GA)	☐	☐	☐	☐	☐

Q2. Did you work with the same type of collaborative partners (i.e. pair or group) for all activities?

- ☐ Yes (if yes then go to question Q3)
- ☐ No (If no. then answer the second part of this question below)

Based on your experience working on the task (s) that require (s) you to work both with two persons and with more than two persons, how will you rate or compare your preference or liking of the tasks

	Strongly preferred ⟷			**Least preferred**
	5	**4**	**3**	**2**	**1**
Working with SAD 1 (i.e. Canvas GA)	☐	☐	☐	☐	☐
Working with SAD 2 (i.e. PECALE GA)	☐	☐	☐	☐	☐

Q3. By choosing my preferred form of collaboration (i.e. either to work in group or pair):					
	Strongly Agree ⟵⟶				**Strongly Disagree**
	5	**4**	**3**	**2**	**1**
I was able to fully participate towards the task	☐	☐	☐	☐	☐
Enjoyed working on the tasks	☐	☐	☐	☐	☐
I was satisfied working with my collaborative partner(s)	☐	☐	☐	☐	☐

Q4: Roughly, how often did you pick the recommended activity?		
☐ Throughout (i.e. 2 time)	☐ Once (1 time)	☐ Not at all (0 times)

Q5: To what scale was the recommended activity in line with your level of preference in terms of the collaborative partners on each activity?			
☐ Over 70%	☐ Around 50%	☐ Below 50%	☐ 0%

Q6: What form of communication(s) did you use mostly or did find convenient to use with your collaborative partner(s) while working on the collaborative tasks (mark all that apply). *(This question target the G2 who worked Online throughout)*

- ☐ Email
- ☐ Canvas message tool
- ☐ Skype
- ☐ Facebook
- ☐ Twitter
- ☐ Viber
- ☐ Whatsup
- ☐ Other (please write it here)…………………………….

Q7: After working with this kind of learning platform that (a) gives you options to choose on how you would like to work on a collaborative task in terms of how many people to work and (b) gives you collaborative partner(s) with similar preference to work with. In your own opinion:

a. What would you say to be the advantage of this kind of approach?
b. What would you say to be the limitations of this kind of approach?
c. What areas would you suggest to be improved?

Q8: To what degree would you choose to use or recommend the use of this kind of platform in online learning in future?

☐ I would strongly choose or strongly recommend
☐ I would choose or recommend
☐ I am not sure
☐ I would not choose or recommend
☐ I would strongly not choose or recommend

Curriculum Vitae

Personal information

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Education and Training

April, 2012 – Sept. 2015	**PhD., Computer Science** Georg-August University, Göttingen, Germany PhD Thesis: Enhancing Personalization and Learner Engagement in Context-aware Learning Environment – A Pedagogical and Technological Perspective Supervisors: Prof. Dr. Dieter Hogrefe, Prof. Dr. Eckart Modrow, Special advisor: Prof. Dr. Ulrike Lucke of Postdam University
Sept. 2006 – Sept. 2009	**M.Ed., Educational Technology** Maseno University, Kenya
Sept. 1998- Sept. 2002	**Bachelor of Education (science)** Maseno University, Kenya Major subject: Computer Science Minor subject: Physics

Work experience

April 2012 – Present	**Research Assistant, University of Göttingen, Germany** Research interests: Technology Enhanced learning (TEL), Distance learning, Context-aware systems, Pervasive learning, Recommender systems in TEL, personalization and collaborative learning
Oct. 2003 – Octr 2011	**Lecturer, Kisumu Polytechnic, Kenya** Department: Computer Department Responsibilities: Teaching, Course Coordination and research coordination
Aug. 2009 – Oct. 2011	**Part-time Lecturer, Masinde Muliro University of Science and Technology (MMUST), Kenya** Department: Computer Science

Additional experience, Training, skills

- Kenya Institute of Education (KIE):
  - Curriculum review and development - computer science program for Technical and Vocational Education and Training (TIVET) division
  - Digital content editing
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Languages

Mother Tongue: **Bukusu**

Other Languages

	Understanding				Speaking				Writing	
	Listening		Reading		Spoken interaction		Spoken production			
English	C2	Proficient User	C2	Proficient User	C2	Proficient User	C2	Proficient Use	C2	Proficient User
Swahili	C2	Proficient User	C2	Proficient User	C2	Proficient User	C2	Proficient User	C2	Proficient User
German	B2	Independent User	B2	Independent User	B2	Independent User	B2	Independent User	B2	Independent User

(*) Common European Framework of Reference for Languages

Awards/ Scholarships

PhD Scholarship: The German Academic Exchange Service (DAAD) in Conjunction with National Commission for Science, Technology and Innovation (NACOSTI) Kenya.

Publications

July 2015

PECALE: An Environment for Enhancing Personalization and Learner Engagement in an Online Learning Platform.
Betty Mayeku, , Sviatoslav Edelev, Sunaina Prasad, Hemanth Karnal, Dieter Hogrefe
IEEE International Conference on Advanced Learning Technologies (ICALT), Hualien, Taiwan

October 2014

Enhancing Personalization and Learner Engagement through Context - aware Recommendation in TEL.
Betty Mayeku
In The ACM Conference Series on Recommender Systems (RECSYS'14), Silicon Valley, USA

October 2013

Towards a Conceptual Framework for Integrating Pedagogy and Technology in a Pervasive DL Environment.
Betty Mayeku and Dieter Hogrefe.
In E-Learn 2013 - World Conference on E-Learning, Las Vegas, USA

July 2013

Could Adaptive Context-aware Pervasive Learning Environment be a Possible Solution to Quality HE and Learner Retention in DL?
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December 2011

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