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Towards Human Activity-Based Interactive Communication Systems' Design in Higher Learning Institutions

Study Conducted in Tanzania Higher Learning Institutions

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Abstract— **The power of human computer interaction in interactive systems' design processes is unimaginable as it determines their usability. However, these design processes encounter several challenges which make most of the designed interactive systems, notably in higher learning institutions fail to suitably satisfy targeted users' needs despite the fact that they are normally designed based on their requirements.**

This study begins by exploring the challenges facing main communication and interaction means used in Tanzania higher learning institutions. The study then provides a review of challenges related to key research areas associated with interactive systems' design. Based on the reviewed challenges, authors combined design science research with activity theory to come up with suited techniques through which user-involved interactive communication frameworks needed for suitable design of human activity-based interactive communication systems' can be obtained.

Based on that approach, authors came up with a suited four phase Design Science Research methodology to be used in designing of applicable frameworks. In its first phase and following a crucial user-centred design process, authors were able to come up with a Human-Activity Design Centred Framework for capturing most of the users' needs in the design process through activities performed as well as a Human Factors' Approach to interactive communication systems design in HLIs'.

Keywords- Human-Computer Interaction, Interactive Systems, Users' satisfaction, Interaction Design, Design Science Research, Activity Theory, Human Factors'.

I. INTRODUCTION

Human-computer interaction (HCI) is a scientific field concerned with the design, evaluation and implementation of interactive computer systems for human use and the study of other major phenomena surrounding them [69][68]. HCI sits upon three broad foundations: theoretical principles, professional practice and a community of people [13]. Interaction Design (ID) is a practice of creating user experiences which improve the way people communicate, interact, and work [78][41]. Essentially, ID is concerned with the design of usable Interactive Systems (INTs') or products. This means easy to learn, effective to use, and provide an enjoyable user experience [46][45]. In essence, HCI is a subset of ID and thus, one cannot be able to come up with effectively designed Interactive Computer Systems (ICSs') without employing appropriate ID techniques [1][33][45].

HCI is concerned with the ways humans interact with information, technologies, and tasks within various contexts [84]. HCI issues include all possible aspects that affect humans interacting with a system during the entire life cycle of the system; thus HCI issues exist during the system design stage, development stage, the use stage, and the system impact

stage [84][69]. This being the case; HCI can play a vital role in providing effective and reliable communication and interaction means in Higher Learning Institutions (HLIs') through suitably designed and implemented ICSs'.

Globally, HLIs' encounter several challenges on how they can bring together all major communicating and interacting parties in these institutions under one interactive communication environment through activities performed [30][48][21][29]. With face to face and phone based communication means use, it becomes hard to bring together these key parties. Alternatively; an online computer-based communication means can have that capability. However, most of the INTs' used in these institutions mainly help to simplify some academic related activities like teaching, learning concerning current students and instructors with activities such as some academic related, financial related, career related, developmental related and the like concerning current and prospective students, instructors and alumni requiring suitably designed Human Activity-Based Interactive Communication (HABIC) systems environments for their simplicity being left behind [16][49][67].

In Tanzania, online computer-based communication difficulties in HLIs' have been among major challenges facing key communicating and interacting parties in these institutions and have now become the source of other challenges which could have been overcame by the presence of a suitable online computer-based communication means [43][12][31]. This communication means can be successfully augmented through well designed and implemented human activity-based ICSs' which at the moment are not given enough attention despite recent growing need for such systems. Most of HLIs' in Tanzania still depend much on phone-based and face to face means of communication in running their key activities with an online computer-based communication means being left less utilized; mainly being used for social communication and interaction issues through general purpose designed systems like social networking websites and email communication systems [83][5][57][64].

According to the principles of effective communication, people have to communicate with all possible means of communication and as effective as possible [19][23][52]. With this being the case; HCI researchers' need to ensure that an online computer-based communication means which normally takes place via ICSs', helps to simplify key activities performed within and possibly outside various organizations. Thus, investigating on how most of the users' needs can be captured by effectively involving them in human activity-based ICSs' design is paramount towards augmenting an online computer-based communication means specifically in HLIs' settings.

Currently, HLIs' in Tanzania mainly depend on Social Networking Websites (SNs') and Email Systems (ESs') for online communication. With ESs'; there is a challenge on how someone can get the contact details of someone else. In most cases these contacts are not easily accessible and even if they could have been accessible the challenge of how to remember a lot of contact details for such a large number people in HLIs' could arise just as in phone-based communication. Also, ESs' communication may suffer from the anonymity challenge as a person can create a fake email address using someone's names aiming at either benefiting from that person's professional status or destructing his/her reputation. This means ESs' do not promote trust among HLIs' community as far as HCI design principles are concerned [50][11] [42][7][78].

With SNs' such as Facebook, Whatsapp and the like; there is firstly the anonymity challenge which makes HLIs' community to be unsure if they are communicating with authentic parties due to SNs' failure on guaranteeing authenticity [4][22]. Secondly, SNs' were designed based on general users' social communication and interaction needs and not based on HLIs' community communication needs, thus can not appropriately help to simplify HLIs' activities [66][73][6][8][65].

Actually, most of the computer systems used in most of HLIs' in Tanzania are mainly for the purpose of enabling certain tasks such as students records, learning and teaching, giving latest news and the like (Joel & Christina, 2013; [36][44][38][56] while the simplification of various key day to day activities between their members and other key partners via online computer-based communication means being not given the much needed emphasize [8][2][65][73]. Required ICSs' need to the ability to simplify individual and organizational goals [15][61][65]. Essentially this has to begin with assuring effective capture of intended users' needs in a particular setting.

Basically, designed INTs' has to take into account both: HCI usability standards in the past which require satisfying ISO 9241 conformance scheme and current HCI usability standards which require designing systems which help simply activities performed by targeted users' in a particular setting [32][65]. Unfortunately this is not the case for most of INTs' used in these HLIs' [56][8][54] [2][65][55]. For example it is still not clear how the activities performed in these HLIs' can be simplified through interacting via an online computer-based communication means. Since Tanzanian government reduced its financial support for the running of various tasks in HLIs' in the country and with the recent COVID-19 challenges then ensuring effective communication is essential for not only quick development of these institutions but also for enabling normal running of key activities through well designed and implemented ICSs' [72][52][23][40].

In fact, the main purpose of HCI is to design INTs' which satisfy targeted users' needs. The user centred design approach ensures that designers involve users in the design process for designed systems to be widely accepted and used effectively [66][73][8][33][32][65]. However, there's still a

problem on appropriate techniques that can be used by designers to easily make users be suitably involved in the design process for effective capture of most of their needs and in turn resulting to INTs' which highly satisfy targeted users' needs (Steen, 2011; [1][20][35][7]. Most of the design techniques so recommended by this approach do help much designers' to get what they need from users' (i.e. user requirements) but they do not help users' to be well involved in the design process particularly through activities performed. As it is, most of these design techniques can only be easily understood by designers' with users' only be involved in requirements gathering and then waiting to be later involved in evaluating already developed prototypes and/or completely working systems. This practice leads to failure in capturing essential users' needs in the design process which could have been vital in the development and implementation phases.

Based on this study, there're still limited design techniques which are capable of making users' be well involved in the design process through activities performed (Steen, 2011; [32][65]. This in turn makes designed INTs' fail to aptly satisfy targeted users' needs despite the fact that they are usually designed based on their requirements [1][65] . Since it is difficult for users' to easily understand and be involved in conceptual models' design aspects, and since HCI uses interfaces to create interactions, then focusing on ID techniques which can easily be understood by users through activities performed could be key in involving users' in the design process and thus guaranteeing effective capturing of most of their needs [33][7][41][65].

This study was guided by two investigative questions as have been provided below and being reviewed in the literature review section in sub-sections 2.1.1 and 2.1.2 respectively.

i. Firstly, "*how can designers employ ID techniques before moving to conceptual model design aspects thereby making users' be well involved in interactive communication systems' design?*"

ii. *Secondly, "how can the user centred design approach appropriately support human activity-based interactive communication systems' design?"*

This paper provides user-involved design-based methods and techniques suitable for HABIC systems' design in HLIs' following the study conducted at the University of Dodoma (UDOM) and Saint Augustine University of Tanzania (SAUT) as well as based on authors' literature review the study's related literature.

II. LITERATURE REVIEW

A. *Interaction Design in Interactive Systems*

Here, the first and main investigative question which guided this study was:

How can designers' employ ID techniques before moving to conceptual model design aspects thereby making users' be well involved interactive communication systems' design?

Interaction Design (ID) is about the design of digital artefacts which we not only use in our everyday lives but with which we co-exist. In particular, ID is about creating user experiences that enhance the way people work, communicate and interact. ID begins with the design belief and the designer's familiarity with the world, then a series of conversations are conducted between the designer and the design (the digital artefact) and between the designer and the client by considering how to iteratively improve the design with respect to its target usability qualities in a targeted setting [33][70].

Most of HCI techniques employed in INTs' design are difficult and complicated for normal users' to understand as they're mainly based on designers' experience and capability rather than users' experience and understanding. Since HCI is a subset of ID, and ID has design techniques like those based on activities performed then it could be better to employ such techniques which can be easily understood by users' before moving to further complicated designer-based techniques like conceptual schema design aspects. This as a result requires finding out techniques to be employed in ICSs' design by combining both HCI and ID techniques.

Despite the fact that several studies have been conducted on HCI and ID but still the question on how techniques from the two aspects can be combined to ensure successful design and evaluation of ICSs' needs to be more investigated. In fact, appropriate ICSs' design has to begin with activity-based ID before moving to conceptual schema design [74][33][7][65]. This is because; it is difficult for users' to be involved in the design and evaluation of conceptual model design aspects. In most cases these design aspects are normally so detailed and complicated to be easily understood by users' as compared to ID aspects which are the roots through which interfaces do come from and can easily be understood by users'. However, most of INTs' designers put more efforts on conceptual models design aspects when compared to the efforts they put on activity-based ID aspects thereby resulting to systems which do not effectively satisfy targeted users' needs [66][65].

Several researchers in HCI and ID emphasize on the design process to begin once identification of users needs have been done [70][66][8][73][33][20] but several issues haven't been clearly explained. For example: is it enough to move straight from requirements identification to conceptual schema design? Or is there something missing between fields obtained results

(i.e. requirements gathered) and the design and/or evaluation processes? Or what actually needs to be designed first (i.e. the conceptual model design aspects or something else like activity-based ID)?

B. User Centred Design Issues

Here, the second investigative question under this review was:

How can the user centred design approach appropriately support human-activity interactive communication systems' design?

As it is, the user centred design approach helps more designers to get requirements from users but it does not give clear explanations and/or techniques on how users may be well involved in INTs' design processes [66][73][8][33][32][65]. This has made users to be only listeners or watchers in the design processes instead of being really participants in this vital design phase leading to failure in capturing most of their needs and hence difficulties in highly guaranteeing their satisfaction with designed INTs' [1][20] [35][7][65].

Based on this review; there is a need for investigating on how the current user centred design approach may be improved based on ID and Human Factors (HFs') aspects to suitably support HABIC systems design and design-based evaluation aspects. This means that a human-activity design centred framework which suitably involve users, needs to be developed particularly in HLIs' settings since most of the users' in these institutions have enough experience on the "how" to use and well interact with different INTs', so, if suitable techniques in ID, HCI and HFs' are well combined, then it will be easy to involve such experienced users into the design process thereby be able to highly guarantee users' satisfaction with intended ICSs'

C. Psychology and Human Computer Interaction

HCI is a scientific field concerned with enabling people to easily interact with computing systems [33]. Design of computing systems is one of the key focus areas in HCI. The aim is to produce systems which are useful, usable, and aesthetically pleasing. A closely aligned area is the evaluation of systems in use. This basically, relates to design, because to know if a design is useful or usable requires observing it in use. Evaluation takes place at multiple levels of analysis: the individual, the group, the organization, and the industry or societal sector [13] [32][51].

Psychology is a scientific study of the human mind and its functions. It deals with human mental characteristics of a person or group of people. Since HCI is concerned with designing interactions between human activities and computational systems then the psychological aspects of human beings; the users of those systems cannot be ignored. To begin with a simple question such as why does HCI need psychology? To answer this question, we take an example of Apple iPhone which is a successful HCI commercial product. If Apple Inc. wasn't well aware of the user's mind, it could not be able to produce such a "user-friendly interface" product. This aimed at changing human life through technological means [27][63].

Psychology in HCI seems simple, but can affect the results of HCI applications [47][74]. Only with an understanding of the psychology of the "people", we understand their needs more clearly and make HCI flow more freely. Thus, as psychologists, we need to focus on both the immediate issues of design and the longer-term consequences for individual and social behaviour.

D. HCI on User Interface Design as Related to Interaction Design

Following this review, it was noticed that designers often have a poor understating of HCI issues. Designers need to know how to think in terms of future users' needs, values, and supportable tasks and how to translate that knowledge into an executable system. This can be accomplished by establishing good interface design techniques which can be successfully achieved by beginning with activity-based ID since these are the roots through which interfaces come from. HCI has two critical dimensions in the development process: firstly, involving users' during the building and implementation of the new system; secondly, evaluation studies about "cognitive and other behavioural factors that come into play when people interact with INTs'" [13][33].

In the past years, HCI experts were consulted later in the design process, but most of the research studies found that this was a mistake. "The Interface is not something that can be plugged in at the last minute; its design should be developed integrally with the rest of the system. It should not just present a pretty face but should support the tasks people actually want to do, and forgive the careless mistakes [13][32]. In Tanzania, most of the used INTs' in HLIs' have been designed based on requirement gathering and analysis processes leaving behind aspects of effective users' involvement through ID under essential human factors [38][55][59]. This implies that the main focus is on interface design through which users' interact with INTs' with less focus on ID through which those interfaces do come from [70][7][41].

Basically, users' do interact with INTs' via interfaces as interfaces are at the higher level with interactions being at the lower level the level of which is actually not seen by users' but it is through which interfaces come from. In reality, HCI is not the science of interfaces just like astronomy being not the

science of telescopes. HCI needs interfaces to create interactions, this means the key focus should be on how to design and evaluate interactions and not interfaces [33][7][41]. Thus, it is important to consider how HCI will fit into the overall design process of INTs' by concentrating not only on good interface design aspects but firstly on good activity-based ID aspects as it is through which interfaces do come from.

E. Human Factors / Ergonomics Issues in Design Process

Human Factors' (HFs') is scientific discipline that focuses on systems in which humans interact with their environment [46][71]. The environment is complex and consists of the physical environment, the organizational environment including how activities are organized and controlled as well as the social environment such as other people, culture [71][81][58][46][74]. HFs' scientific discipline may be well explained based on three major approaches to HFs' [71].

Firstly, HFs' may take a systems approach [71][14]. Fundamentally, a system is a set of interacting and interdependent components that form an integrated whole [71][14]. HFs' discipline focuses on goal-oriented and purposefully designed systems consisting of humans and their environment [14][71]. The environment can be any human-made artefact such as work place, tool, product, technical processes, service, software, built environment, task, organizational design as well as other humans [81]. Several aspects of a particular person such as physical, physiological, psychological (affective and cognitive), social and different aspects of the environment such as physical, social and informational are normally taken into account as HFs' [46][81].

Secondly, HFs' may also be considered to be design driven [14][71]. HFs' seeks to improve performance and wellbeing through systems' design, analysis, assessments as well as recommendations for the design [14]. HFs' can be involved in all stages of planning, design, implementation, evaluation, maintenance, redesign and continuous improvement of systems [14][82]. HFs' specialists' have to be active participants in design processes [9]. This means that those who will be part of the system being designed are often brought into the development process as participants [10].

Finally, HFs' has effect on two outcomes: performance and wellbeing [18][71]. These do relate through finding the possibilities of fitting the environment to human where two related system outcomes can be achieved. Firstly: performance aspects such as productivity, efficiency, effectiveness, systems security, reliability and secondly, wellbeing aspects such as health, satisfaction, learning, personal development [18][71]. These and other outcomes are balanced by HFs' specialists, managing practical as well as ethical trade-offs within systems [14]. Performance and wellbeing interact and influence each other. For example; humans may perform below their capabilities because other parts of the system are obstacles rather than providing a supporting environment [62][59][14].

Thus, HFs' are vital in the design, development and evaluation of INTs' as it is through these factors intended users' needs' can be easily met thereby assuring their satisfaction with designed interactive systems.

Following this review it was noticed that there's a need for finding suitable techniques and/or methods which can easily make users be suitably involved in the design and design evaluation aspects of INTs'. This may be found by investigating on how HCI, ID and HFs' research areas can be combined to come up with techniques which may help boost users' involvement in the design phase aiming at capturing most of their needs in this vital phase and eventually guarantee users' satisfaction with designed INTs'. This is due to fact that INTs' are normally designed for users' and so they should fully be for users' [32].

Fundamentally, users' involvement in INTs' design is the main HCI purpose [32]. This being the case; investigating on how HCI, ID and HFs' can be combined to ensure that users' are suitably involved in the design and design evaluation is vital for coming up with appropriate interactive communication systems' design in HLIs'.

Based on this review, several studies have been conducted on the user centred design aspects [35][20][73] but limited studies have been conducted on the question on how HCI, ID and HFs' techniques can be combined to come up with essential techniques for guiding successful design and design evaluation aspects of ICSs'. Essentially, required techniques should be those which can be easily understood by users' and in turn make them be suitably involved in the design process for effective capture of most of their needs [33][7][59][46][28][63][14]. Figure 1 illustrates the dependencies between HCI, ID and HFs' based on this investigation.

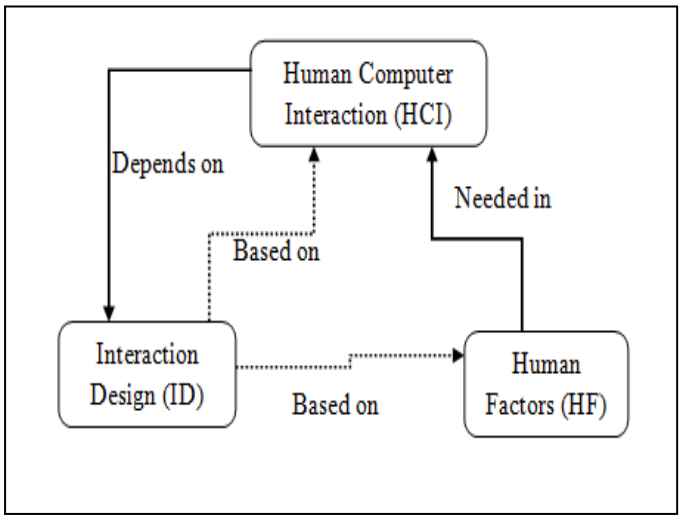


Figure 1. HCI-ID-HFs' dependencies

F. Activity Theory in Human Computer Interaction Levels

Activity Theory (AT) is a general theoretical framework for the analysis of human and communal action in the world [37]. It is a theory for analysis, describing and studying design rather than as a theory for prediction [37][17]. Two main ideas comprise the foundation of AT; the social nature of human mind, and unity and inseparability of human mind and activity. AT later became an interdisciplinary framework, employed not only in psychology but also in education, organizational learning, and HCI [37].

In this review, five different roles for HCI researchers aiming at making AT work have been identified. Firstly: the meta-theoreticians who considered AT itself as an object of analysis. Secondly, theory-tool-makers used AT as a theoretical influence in the development of a new analytical tool. Thirdly, AT was employed by developers as a tool for conceptual analysis and development. Fourthly, AT was used by data interpreters as a tool for empirical analysis. Lastly, AT was used by design-oriented researchers as a framework for design [37].

Based on this review; AT is considered to be a promising approach to work-oriented and participatory information systems design and development and thus was found to be suitable for guiding this study. The theory was employed in combination with other design strategies to aid the investigation on suitable techniques and methods through which HABIC systems in HLIs' can be suitably designed and in turn guaranteeing augmenting communication and interaction in these institutions.

III. METHODOLOGY

A. Study Approach

This study aimed at developing and recommending HABIC systems' design methods and techniques capable of enabling effective users' involvement [32][65]. This being the case; qualitative research methods such as face to face interviews, personal observation, focus group discussion as well as cause and effect strategies were employed [39][80][32].

B. Study Paradigm

The study paradigm of Design Science Research (DSR) was selected for this study. DSR is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of scientific evidence [25][26] Baskerville *et al.*, 2018). DSR was found to be suitable for this research since the focus was on construction of design-based methods, techniques and approaches.

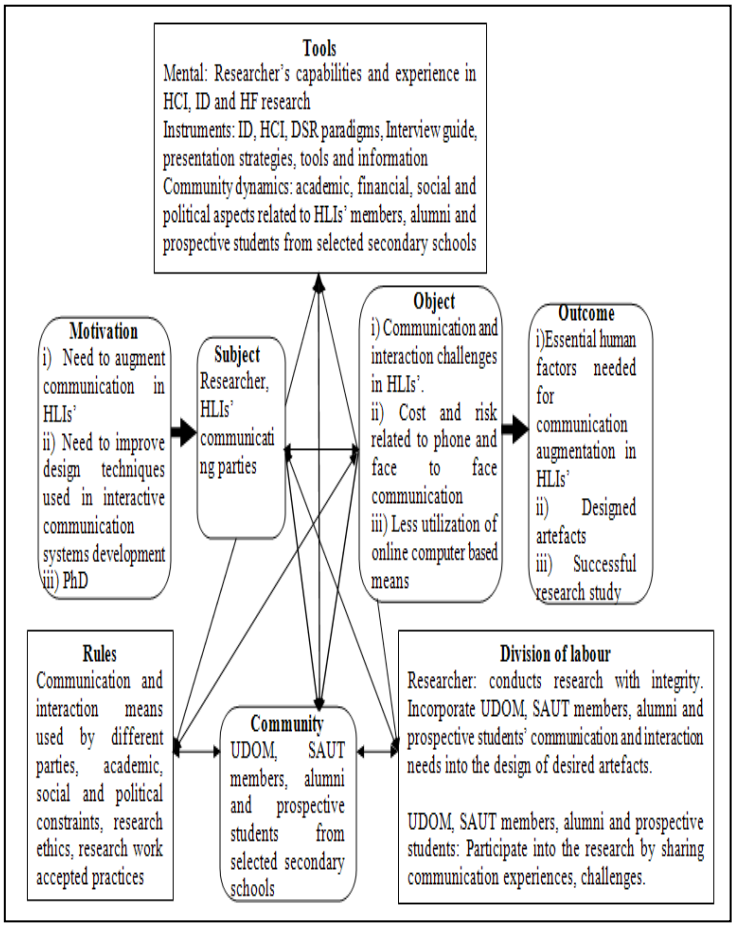
C. Study Strategies

This study combined both: DSR methodology with Activity Theory since the focus was to come up with methods and techniques suited for designing HABIC systems' to be used in augmenting communication and interaction based on key activities performed among major communicating parties in HLIs'. While the DSR was used to guide the building of the intended methods and techniques, the Activity Theory (AT) was used to complement the DSR thereby simplifying the incorporation of key activities in the methods and techniques developed.

D. Design Science Research Methodology

This methodology was found to be suitable for this study as it was selected from the DSR genre prototypes (Ken *et al.*, 2018). This is because the study aimed to come up with design-based techniques needed for HABIC systems' design in HLIs'. This methodology relies on iterative processes based on three cycle model which are relevance cycle, design cycle and rigor cycle.

The relevance cycle bridges the contextual environment of the study with the design science activities. The study environment comprised of people in HLIs' and prospective students, organizations which included: the University of Dodoma (UDOM), Saint Augustine University of Tanzania (SAUT) and selected secondary schools, technological systems: HLIs' official websites, students' records systems (SR), SNs', and other used content management systems. On the rigor cycle, the existing knowledge base provided a



foundation for this study. The literature on HCI, ID and HF provided basis for building intended techniques.

Lessons learnt from the design cycle were documented to augment the knowledge base on how HCI, ID and HF can be combined to aid the research on appropriate techniques capable of making users' be suitably involved into the design process. The results of the rigor cycle were used in the design cycle. Iterations of build and evaluation were conducted under design cycle until satisfactory design techniques were achieved. Additions to the knowledge base as results of DSR included the developed methods, approaches as well as all experiences gained in the entire study [3]. Figure 2 below illustrates.

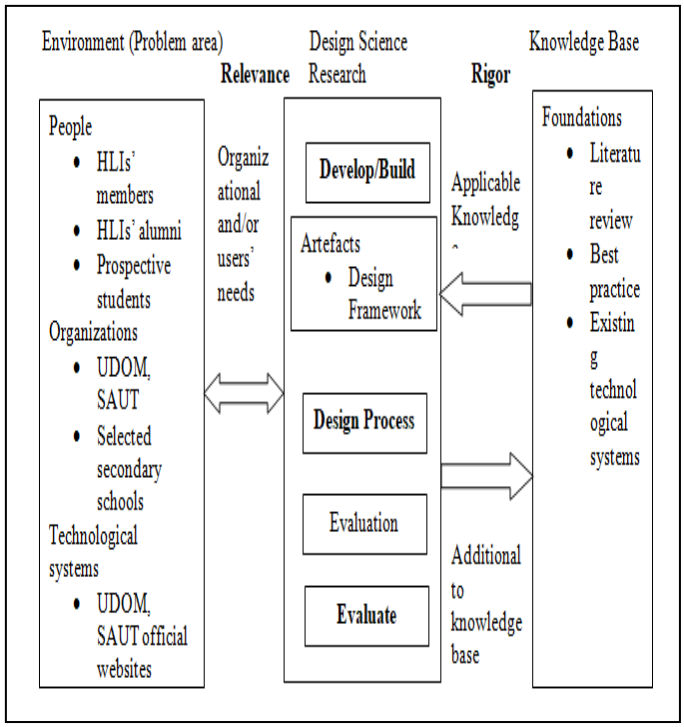


Figure 2. Design Science Research Methodology (Adapted from [25][26])

E. Activity Theory Components in this Study

In this study, third generation Activity Theory (AT) was applied in the design of the intended methods and techniques as s illustrated in figure 3. The choice of third generation AT was based on the fact that it is an AT generation which has been successfully and extensively used to analyze case studies in professional communication and related fields such as information systems, workforce education, and computer-supported cooperative work [37]. Figure 3 illustrates.

Figure 3. Activity Theory Coponents Employed (Adapted from [17])

IV. RESULTS AND DISCUSSION

The results were grouped into four main groups. Firstly, results from analysis of existing communication and interaction means, tools used at UDOM, SAUT as well as communication and interaction problems and opportunities. Secondly, results from the four phases design science research methodology proposed. Thirdly, results from the human activity-centred framework proposed and finally results from the designed human factors' approach to HABIC systems design in HLIs'.

A. Comommunication and Interaction Problems Analysis and Opportunities

Cause and effect analysis strategy was used to determine the causes and effects of communication and interaction problems persisting at UDOM, SAUT and visited secondary schools. Tables I and II below shows the results of the causes and effects analysis strategy.

TABLE I. CAUSE AND EFFECT ANALYSIS STRATEGY SUMMARIZATION

Problems	**Causes and Effects**	**Design objectives**	**Design Constraints**
Online computer-based communication difficult due to several challenges: -Current existing systems do not provide the required interactivity and only certain parties are given access to those systems. -Lack of INTs' designed and implemented for the purpose of simplifying key activities taking place among major communicating and interacting partie	-Lack of suitably designed interactive communication environments -Designers lack enough experience of HCI concepts incorporation in systems design -Lack of extensive research before designing intended systems -Lack of enough knowledge for systems designers to concentrate much on interaction design before going for	Design human activity-based ICSs' which provide the required interactive taking into account interaction design requirements and enabling only HLIs' members, HLIs' alumni and prospective students' to have access to appropriately designed interactive communication environments. Use suitable interactive communication environments according to different sets	Required ICSs' should be designed based on well investigated human activity-based interactive communication frameworks designed based on well researched HFs' approach to ICSs' design based on key HFs' analyzed on targeted participants

Problems	Causes and Effects	Design objectives	Design Constraints
	interface design (i.e. more effort is kept on interface design rather than interaction design) -Lack of enough knowledge particularly for top level management on communicating and interacting via human activity based ICSs' in these institutions thus ignoring putting more effort on investing on how to sitably implement such systems. Financial problems as not enough fund is reserved for paying researchers to go for extensive research before systems are designed and for paying professionals and experienced systems designers and developers for appropriate designs and implementations	of activities performed based on targeted participants' human factors' analyzed	

TABLE II. CAUSE AND EFFECT ANALYSIS STRATEGY SUMMARIZATION

Problems	Causes and Effects	Investigation Objectives	Investigation Constraints
Face-to-face communication difficult.	-Rapid increase in the number of students enrolled in each year -Expansion of investigated HLIs' into schools and colleges -Expensive due to transport hardships, family and work responsibilities -Recent COVID-19 communication and interaction challenges	Switch to online computer-based means of communication through the use of ICSs' being designed based on suitable HFs' approaches to ICSs'.	Ensure availability of appropriate interactive communication environments based on different sets of activities performed.
Phone-based communication difficult.	-High expenses of using phones in communication -Fear of being disturbed by receiving many calls from unknown persons -Challenge of how to remember a lot of contact details for such a large number of HLIs' members, HLIs' alumni and possibly prospective students.	Switch to online computer-based means of communication through the use of ICSs' being designed based on suitable HFs' approaches to ICSs'.	Ensure availability of appropriate interactive communication environments based on different sets of activities performed.

B. Four Phases DSR Methodology for HABIC Systems' Design

The Figure 5 describes the four phase DSR methodology employed for guiding user-involved design of HABIC systems' in HLIs'. The methodology positions AT in the design and demonstrates activities, and shows how the outputs needed to be integrated towards the final methods and techniques designed. This four phase DSR methodology was developed based on the literature review conducted on DSR and AT and then being linked with the challenges facing the case study areas under this investigation. Figure 4 below illustrates.

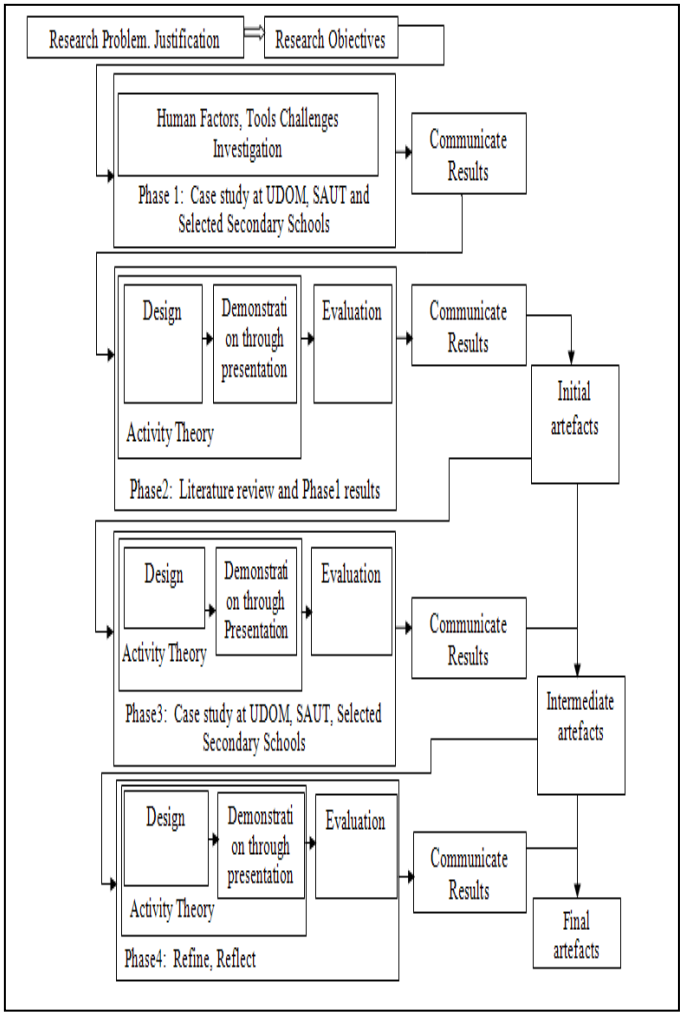


Figure 4. Four Phase DSR Methodology Suited for HABIC Systems Design in HLIs' (Adapted from [24][25][26])

Phase 1:

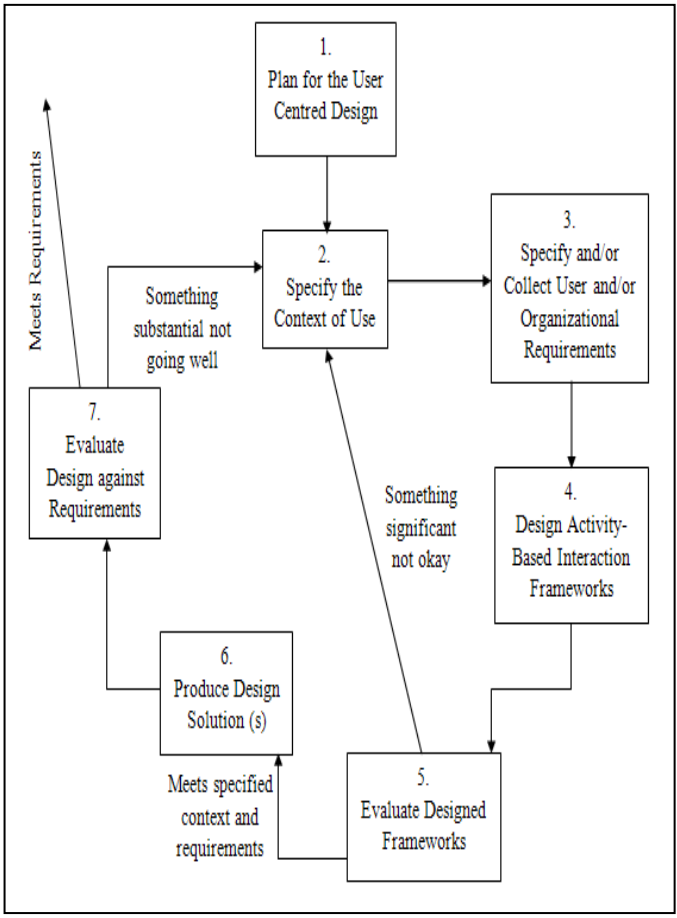
Involved targeted users' (i.e. HLIs' members, HLIs' alumni, Prospective students), as well as HCI and ID researchers. Here HFs' essential for ICSs' design were analyzed based on challenges affecting existing communication and interaction means, other tools used as well as based on the literature survey conducted. Finally, HFs' Approach needed in guiding the design process of HABIC systems' was constructed. This HFs' Approach is suited for analyzing targeted users' HFs' in HLIs' settings.

Phase 2:

Involved targeted users' (i.e. HLIs' members, HLIs' alumni, Prospective students), as well as HCI and ID experts as well as INTs' designers. Here Human-Activity Interactive Communication (HAIC) framework was designed based on the following:

Different sets of activities performed among key communicating and interacting parties,

Activities were classified based on main HCI paradigms of cognitive revolution based, situated perspective based and human performance and wellbeing [77][32],



Different types of interactive environments through which those activities may be communicated through were identified,

HFs' approach obtained in phase 1 was used as a guiding tool in this phase,

Evaluation of designed HAIC framework was done under qualitative evaluation strategies. The results in this phase were then communicated in phase 3.

Phase 3:

Involved targeted users' (i.e. HLIs' members, HLIs' alumni, Prospective students), as well as HCI and ID experts, INTs' designers' and INTs' developers. Here the HAIC framework constructed and evaluated in phase 2 was again well modified and reconstructed based on the evaluation results obtained in phase 2. Final frameworks in this phase have to be evaluated based on ID frameworks evaluation dimensions [41] where qualitative evaluation strategies have to be employed.

Phase 4:

This phase was the final phase with the main concentration being on complete evaluation of designed HAIC framework. This phase involved targeted users' (i.e. HLIs' members, HLIs' alumni, Prospective students), HCI and ID experts, INTs' designers' and developers as well as professional user interface designers' who were not necessarily required to be programmers. In this phase, qualitative and quantitative ID frameworks evaluation dimensions [41][51][80] were employed. This mixed approach evaluation strategy as recommended in the field of computing aimed at assuring the quality and capability of the designed HAIC framework to successfully guide the design of ICSs' as well as there acceptability to targeted users'.

C. Human-Activity Design Centred Framework

Based on the study's related literature and following the interviews as well as focus group discussions conducted among SAUT members, UDOM members, their respective alumni as well as prospective students in selected secondary schools, it was found out that the current user centred design approach needs to be enhanced to easily support capturing of most of the users' needs through activities performed. Figure 5 below illustrates more. A detailed discussion is then provided on two new key stages in the developed Human-Activity Design Centred (HADC) framework based on this study. The new stages were introduced soon after stage three of the user centred design approach as illustrated below

Figure 5. Human-Activity Design Centred Framework (adapted from Sutcliffe *et al.*, 2011; Steen, 2011;[32]

The HADC framework above illustrates key stages which should be passed through in the design of ICSs' with the capability of highly guaranteeing users' satisfaction with resulting activity-based ICSs'. This framework was developed based on both: firstly, the focus group discussion conducted among involved participants' in the two HLIs' investigated, and secondly, authors' experience with the user centred requirements engineering and the usability as well as other vital HCI issues regarding INTs' design (Sutcliffe *et al.*, 2011; Steen, 2011; [32].

Stages four and five in HADC framework employed, as illustrated in figure 4 above, are the two new stages introduced in the existing user-centred design approach. Following this study, these two stages are not clearly being explained by most of the ID and HCI researchers as to when and where they've to be employed [66][73][8][33] Steen, 2011; [32][65]. This lacking explanation has been complicating for a long time the efforts made by most of INTs' designers in the quest of finding effective ways to capture most of the users' needs particularly in INTs' design processes. As it is well known, INTs' are designed for users', thus should be for users' [65].

Stage four (4) which is Design Activity-Based Interaction Frameworks was done based on activities performed by targeted users'. Keeping in mind the fact that activities performed are different from requirements gathered then several vital questions had to be well investigated here. For example; how do users' do what they do? How do they interact? What are activities do they perform? What types of INTs' environments do suite different types of activities they do? These key questions were used as design guides during this stage. This stage involved ID and HCI researchers', targeted users' as well as other key stakeholders who in one way or another were found to be part of the users of the intended ICSs' to be designed.

Stage five (5) which is Evaluate Designed Frameworks required the expected frameworks to be designed in such a way to be easily understood by intended users' so that they may easily put their inputs for improving the designed frameworks. This stage was done by involving targeted users', ID experts, INTs' designers' and professional user interface designers' who were not necessarily required to be programmers where both qualitative as well as quantitative evaluation techniques were employed [79][80].

Designed and well evaluated frameworks from stage (5) will then be used as design guide by designers' in stage (6) where conceptual schema design aspects which in most cases involve mostly INTs' designers' take place. Having these designed and evaluated frameworks will help INTs' designers' involved in this stage to have a practical guidance on how interactions take place based on activities performed in a particular setting than only relying on the theoretical aspects of conceptual schema design requirements [60].

The major difference between this HADC framework and the user centred design approach is that this HADC framework has clearly illustrated and described how ID design aspects should be done during INTs' design process, who should be

involved and exactly when. These design aspects are not being clearly explained in the user centred design approach [84] [76][33][65]. These user-involved ID aspects are vital in assuring that the design process does not only focus on organizational aspects of the design but also on human aspects of the design. This lacking explanation was confusing most of INTs' designers on how to make users' be suitably involved in INTs' systems design processes leading to difficulties in highly guaranteeing users' satisfaction with designed INTs' [65][45].

D. Human Factors' Approach Design

The designed HFs' approach was obtained during phase 1 of the four phase DSR methodology following a crucial user centred design process where the need for suitable approaches capable of analyzing HFs' needed for HABIC systems' design process arose [71][59]. This approach was considered suitable for enabling easily capture of key HFs' since it emphasizes on finding the possibilities to improve quality of working life by considering both: the negative outcomes from non-use of systems and the positive outcomes from the technological use of systems based on activities performed. Figure 6 below illustrates.

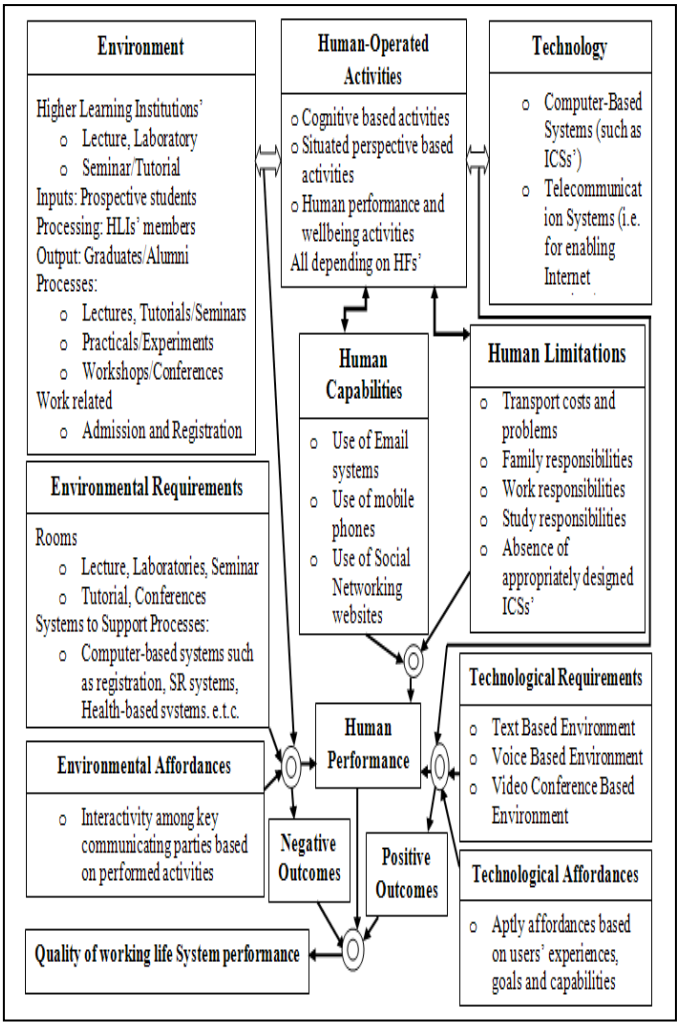


Figure 6. Human Factors' Approach to HABIC Systems' Design in HLIs'

This approach requires the design of HABIC systems' in HLIs' settings to be done by considering several key aspects: firstly, based on different sets of activities performed and so communicated, secondly, based on capabilities of key communicating and interacting parties in HLIs' to use the intended systems under suited interactive communication environments, thirdly, based on the required technologies and technological requirements supporting the activities performed by different major communicating and interacting parties, lastly, ensuring that designed HABIC systems' should be well evaluated under HLIs' environment settings and HCI design-based evaluation aspects based on human limitations to ensure that they could in turn lead to development of HABIC systems' which improve targeted users' performance through activities performed.

This approach was designed based on three key HFs' characteristics governing the design of INTs' which take into account HFs' aspects. These characteristics are HFs' taking a systems approach, HFs' focusing on two related outcomes: performance and wellbeing and HFs' as design driven.

Firstly, with HFs' taking a systems approach; the designed HFs' approach has to a large extent focused on the goals and purpose of expected HABIC systems' to be designed. Different types of interactive environments suitable for communicating key sets of activities have been well illustrated.

Secondly, with HFs' on performance and wellbeing; the designed HFs' approach has illustrated how the design of intended HABIC systems' should be done by considering human capabilities, and limitations in using different types of related INTs' so used by different categories of targeted users' involved in a particular study. These will in turn have a huge effect on their activities performance. It will be the task for INTs' designers', developers' to ensure that expected designed and developed HABIC systems' do improve targeted users' performance through improving their productivity, efficiency, effectiveness, quality and innovativeness by ensuring that they're designed in a secure way to be used by only targeted users', while at the same time being reliable and sustainable. The well-being attribute has to be achieved by ensuring that deigned HABIC systems' are enjoyable and safe to use, satisfy targeted users' needs, and do help to support personal development by enabling easy learning process through interacting with each other via suitably designed interactive environments.

Thirdly, with HFs' as a design driven discipline; the designed HFs' approach has to be key in all stages: planning, design, implementation, evaluation, maintenance, redesign and continuous improvement of intended HABIC systems. These stages may not necessarily be sequential, they are recursive, interdependent, dynamic, but design is at the heart of them. This being the case; HFs' specialists should be active participants in HABIC systems design processes. This means that HABIC systems' have to be designed by not only being governed with acceptable usability standards such as IS 9241 for quality of use applicable for the design of INTs' and others acceptable standards like ISO 13407 governing the design

process under the user centred design process but also by being governed by vital HFs' approaches designed in a particular setting where intended HABIC systems may need to be designed and implemented.

This HFs' approach was a vital input in phases 2 and 3 of the four phases DSR methodology employed in this study.

V. DISCUSSION

This section provides an evaluation for the main investigative question as it was provided in the literature review section A. This was the key study question. Authors were able to evaluate appropriately the answers for this question following this study. This was done following the authors' personal observations, literature review on the studies related literature, interviews, focus group discussions with targeted participants' at UDOM, SAUT and prospective students' in selected secondary schools located in Dodoma, Mwanza and Iringa regions in Tanzania.

Study Question Evaluation

> *"How can designers employ ID techniques before moving to conceptual model design aspects thereby making users' be well involved interactive communication systems design?"*

Following the interviews and focus group discussions conducted among SAUT members, UDOM members, their respective alumni as well as prospective students in selected secondary schools, it was found out that most of these targeted participants' involved had very little understanding or completely no understanding of conceptual schema design aspects used in INTs' design processes. However, most of them had clear understanding of different types of key activities performed in HLIs' settings. This propelled a need to investigate how they may be involved in the design process through activities performed. As a result of this, authors' opted to put more efforts on investigating different types of key activities performed rather than conceptual models' design issues since most of HFs' aspects could be easily captured through involving users' in activity-based ID process which were found to be easily understandable to them as compared to conceptual schema design aspects which are so detailed and difficult for normal users' to understand.

The study revealed that appropriate HABIC systems design has to begin with activity-based ID aspects before moving to conceptual model design aspects. This was mainly due to the fact that it was easier to capture most of the users' needs in activity-based ID stage following a critical user-centred design approach conducted among participants' involved. This stage has to follow soon after requirements gathering stage instead of moving straight from requirements gathering stage to conceptual schema design aspects where most of the users' needs may be left unconsidered during this design process. The output of activity-based ID may be used as a design guide to INTs' designers' during the conceptual schema design stage and other detailed design stages (such as interface, navigational, database models) the stages of which are complicated for normal users' to understand and thus difficult for them to be involved in.

CONCLUSIONS

In order to successfully involve users' into the design process of INTs' for the purpose of capturing most of their needs; there is a need to understand which design aspects may be easily understood by users based on key research areas related to INTs' design. This study attempted to analyze techniques and methods needed for the design of HABIC systems' in HLIs' particularly in Tanzania settings. This paper is conceptual in nature. The approach taken on in this paper was initially to set the study context by presenting the existing literature on the HCI, ID and HFs' research areas where the HCI-ID-HFs' dependencies framework was developed. Authors' then analyzed the user centred design approach based upon the perspectives from existing literature and targeted users' views and capabilities in being involved into the design process and then designed a HADC framework capable of supporting the designer-user inclusive design approach. This framework then led to the development of an HFs' approach to HABIC systems design during phase 1 of the four phases DSR methodology developed and employed under this study.

The literature review of relevant research areas related to INTs' design has identified three significant issues. First, there is little evidence of research studies that provides a significant scientific explanation on how users' may be suitably involved in INTs' design processes. For example, the question on how activity-based ID can be done to aid the design of INTs' which highly satisfy targeted users' needs is still hanging and so needs to be more investigated. Second, the current research studies are limited to the theoretical and practical aspects of conceptual schema design with limited research on interaction design through activities performed and how this may be well done. This makes difficult for users' to be suitably involved into the design process since normal users' cannot easily understand conceptual schema design aspects and thus cannot be well involved into that design stage involving such aspects. Failure to effectively involve users' into the design phase leads to failure in capturing key users' needs into this vital phase thus complicating the chances of highly guaranteeing users' satisfaction with designed systems.

Third, existing studies have tried to explain HCI, ID and HFs' research areas separately with limited focus on how they can be combined for successful design of ICSs'. Most research studies have explained these areas separately thereby leaving INTs' designers confused on how they may successfully employ techniques and methods so recommended from these areas. In most cases, most of INTs' designers' do rely on certain design methods which they find easy for them to employ while neglecting other design techniques which they think are difficult for them to employ or may cause the design

process to take a long time but could be vital in guaranteeing users' satisfaction with designed INTs'.

This paper therefore, recommends more research on how users' may be suitably involved in INTs' design process by investigating more on essential techniques and methods which can be easily understood by users' and make them be well involved into the design process as it is through which successful design of HABIC systems' which highly guarantee targeted users' needs can be achieved.

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