TURNING LEMONS INTO LEMONADE. THE PRACTICE OF USING INSTANT MESSAGING FOR TEACHING PROGRAMMING.

Manduna Watson Moffat, Prof Goede Roelien, Prof Drevin Lynette
Faculty of natural and agricultural Sciences
Northwest University, Potchefstroom Campus

ABSTRACT

The world we live in is complex such that only data driven innovators who, are able to: (a) push boundaries; (b) acknowledge the 'science' (for continuous learning, critique learning, self-organisation, inter-connection/dependence); and (c) practice the 'art' (to pragmatize diversity, openness, connectivism) of the unimaginable (admittance of emergent phenomenon) can survive.

In educational settings, complexities exist in various forms, which includes the 'haves' and 'haves not': e.g., access to/not to the study content and environment. In developed countries, teaching/learning tools like learning management systems (LMS) are used by students, a privilege that does not exist to schools/colleges students in most developing countries; especially those whose parents have low incomes. Older mobile phones are the only technology available to the students because of their capabilities (e.g., manageable costs and ubiquitous). Although the prospects of using mobile phones with applications such as instant messaging (IM) in education exist; due to complexities (i.e., organizational; individual; micro, macro and meso forms); most millennium learners who have access to IM, do not use it for learning.

The aim of this paper therefore is to present a study that shows how to make a difference; to emancipate the affected/involved (students, teachers) in achieving the seemingly impossible through using IM for teaching in order to reach their full potential as learners/teachers. This paper reports on the preparatory literature review done to develop guidelines for using IM in computing training from a critical systems perspective, through the ideas of Werner Ulrich, based on Kant's work on conditioned realities. Koehler and Mishra's technological pedagogical content knowledge framework (TPACK) is applied to elucidate different types of perspectives (in form of technical, pedagogical and content boundaries), essential in dealing with the complex educational ecosystem.

Sequentially (from widest view to a narrow), through TPACK the first phase of the technological knowledge of the study (TK); as the main boundary, is discoursed in accordance with 'conditioned realties' of the 'art' and 'science' of HCI to produce initial guidelines for developing software. Due to the critical systems' idea of an environment; a pragmatic review

of the initially produced HCI guidelines is done with regards to IM restrictions/affordances; for the development of the initial guidelines in relation to HCI and refinement thereof for IM.

The second phase the study's pedagogical knowledge (PK) is provided through a detailed theoretical review of literature on education and programming education. The discussed intersection of the TK and PK of the study is centred on the understandings of the affordances/restrictions associated with the study's technological and pedagogical understandings. The obtained knowledge is applied to the previously developed guidelines to produce a set of refined guidelines.

The third phase of the study's content knowledge (CK) is presented in respect of Java programming concepts. The interrelationship of the CK and: (1) TK is discussed in tandem to technologies that are used for performing and understanding that science; (2) PK, offered is based on the: motives of teaching programming; concepts to be taught; familiar students' programming difficulties or misconceptions; and the way to teach a topic. A pragmatic review is also done on the previously refined guidelines to obtain another set of (final) enhanced (centre for all the knowledge connections; TPACK) guidelines. In future work, these literature-based guidelines will be imperially tested/verified and used to assist in the development of a framework for using IM in computing training in secondary schools, technical and vocational education and training colleges from a HCI principle and critical systems perspective.

Key words: critical systems thinking, technology, technological pedagogical content knowledge framework, human computer interaction, computer programming education.

INTRODUCTION

There is messiness/complexity everywhere. The messiness is classified by several occasionally contrasting tools/practices (Lee and Hannafin, 2016:712; Veletsianos, 2016:22). These tools/practices include institutional politics; digital environments; learner expectations; and ill-structured problems (Lee and Hannafin, 2016:712; Veletsianos, 2016:22); any other wicked problems.

In educational settings, there exits blurring roles between: source/expert and amateur of information; author and audience; educator and learner (Veletsianos, 2016:69), thereby raising concerns (i.e.,

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legitimacy). Traditional information foundations have been transformed; the means for producing information is accessible to anyone in the society, unlike in a controlled hierarchical epoch (Siemens, 2008b:5). Presently, the growth of information surpasses people/organizations' ability to manage its profusion (Boyack, 2004:5192; Siemens, 2008b:7). Information source includes community resources, multiple medias (aural, graphical, and textual), libraries (Bundy, 2004:3); database, websites: wikis, forums and blogs (Siemens, 2008a:5; Duke et al., 2013:6).

Under these circumstances, only data driven innovators who, are able to: (a) push boundaries; (b) acknowledge the 'science'; and (c) practice the 'art' of the unimaginable are able to survive. It should however be noted that all the notions (i.e., systemic) discussed in this paper are offered in their brief formats in the context of a bigger theory perspective.

Current educational settings are faced with challenges that include the way to stipulate learning processes/contents in accordance with the digital age (Siemens, 2006b:9; Şahin, 2012:439). The structured/hierarchical setting (categorized by some learning environments) is no more favourable for informal learning, preferred by learners (Siemens, 2008b:5; Veletsianos, 2016:69). Today millennial students, who are raised with technology: (1) are more technically skilled than their lecturers/teachers (Veletsianos, 2016:69; Himmelsbach, 2019); (2) desire learning material which is in the similar technical milieu as they are accustomed to (Farmer, 2003:5; Kukulska-Hulme *et al.*, 2011:220), in place of the out-dated methods (Veletsianos, 2016:83); (3) favour to express their opinions through brief formats (Shift, 2018); (4) desire to acquire the story's idea from an condensed source, not from lots of pages (Shift, 2018); and (5) demand the easy accessibility (anytime and anywhere) to information (Shift, 2018).

In developed societies, schools/colleges students can use high-tech teaching/learning tools (i.e., learning management systems), an honour that may be non-existent to students in many poor societies. Old mobile phones are the only technology available to the students because of their capabilities (e.g., manageable costs and ubiquitous). According to literature, the mobile phones usage prospects with applications like instant messaging (IM) in education environment exist. However, most millennium students are digital/technology skilled who: (1) have access to IM; (2) nonetheless are reluctant to use technology in learning settings (Himmelsbach, 2019).

Therefore, this paper is aimed at presenting a study that shows how to make a difference; to emancipate the affected/involved (teachers, students) in achieving the seemingly impossible through using IM guideline for teaching; in order to reach their full potential, as teachers/learners. To achieve this, systems notions (i.e. systems, systems thinking, critical systems) are used to provide a theoretical foundation of the study. Checkland and Holwell (1998:15)'s framework for a reflective practice in action research is utilised to guide the study; by establishing the position, interaction and reflectiveness of the assumed framework(s), methodology, the area of concern and the obtained understanding. Ulrich's concept of a system as a sum of conditioned realities is applied as a means to pragmatize the action research study through providing multiple perspectives (as conditioned realties) and make them transparent for mutual understanding.

Koehler and Mishra (2005a)'s technological pedagogical content knowledge framework is utilised as a means to reflect on different conditioned realities with reference to technological, pedagogical and content knowledge. A critical review of these conditioned realities is therefore done, to produce literature-based guidelines that can be used for the envisioned teacher/learner emancipation.

This paper is used to report on the preparatory literature review done to develop guidelines for using IM in computing training in schools/colleges from human computer interaction (HCI) principles and IM constraints guided by critical systems thinking.

The paper starts with a description of the methodology which guides the structure of the paper.

METHODOLOGY

Checkland and Holwell (1998:15)'s framework for a reflective practice in action research is applied to guide this study, where *methodology (M) is applied to explicit associated thoughts' theoretical view (F) in order to study the area of application (A). This framework (FMA) is appropriate to this critical social research study since the utilisation of M enlightens stakeholders about the situation of A and the aptness of (F) and (M) (Checkland and Holwell, 1998:13); i.e.* the usage of a checklist on boundary judgements on A revealed among other things: beneficiary (secondary school learners technical and vocational education and training

students as primary); measure of improvement (active participation of the learners as well as autonomy of the students).

The F is employed to examine the appropriateness of M (West and Stansfield, 2001:268). Eventually, the anticipated kind of the learning from the framework include: (a) understanding of the theoretical foundation from which the action began from F, and (b) understanding about the means in which action was undertaken on M and enhancement in A (West and Stansfield, 2001:255); and (c) reflections through F and M on the practice, where changes are made thereafter as depicted in **Error! Reference source not found.**.

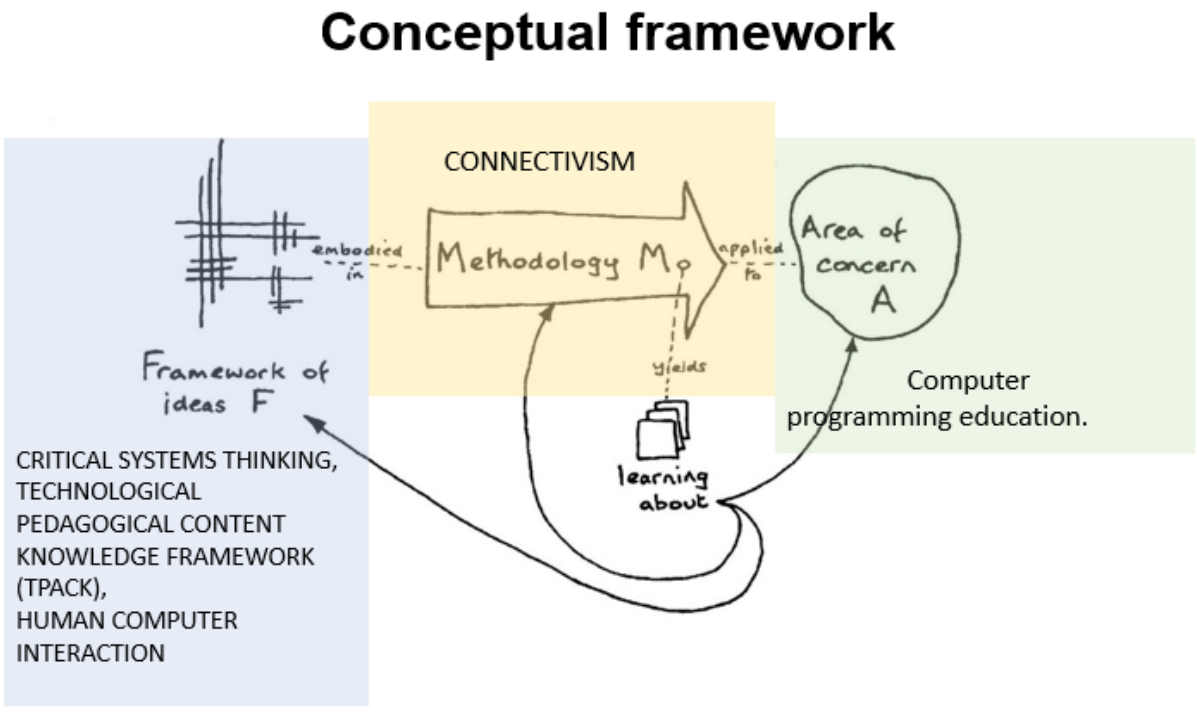

Figure 1:The organized use of rational thought, as a theoretical framework for the study (adapted from Checkland and Holwell, 1998:15).

The learning about, in the FMA, means new understandings can be obtained from F, M and A, that can influence one or both elements (e.g., understandings obtained from A may impact on the selection of F or M and even change it).

This study's methodology is characterised by the systematic devotement of the guidelines. Accordingly, the learning about, in the FMA, means new understandings are obtained from F (the technological knowledge, i.e., HCI), M (pedagogical knowledge, i.e., connectivism) and

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A, where a continuous reflection on the learning about brought multiple perspective, as conditioned realities in form of guidelines.

The discussion of the paper starts with TPACK, in context of critical systems thinking in Section 3; as the overall guidance to the development of the guidelines, which are presented in phases of development in Section 4. This is followed by a reflection in Section 5.

TPACK IN CONTEXT OF CRITICAL SYSTEMS THINKING

Critical systems thinking

In this study systems, is understood in consistency with Reynolds and Holwell (2010a:251); Ulrich and Reynolds (2020:263)'s view, as a conceptual construct (not real-world structure), essential in comprehending circumstances and engage with numerous perceptions.

Systems thinking, was remarked in this study in relation to its historical evolution, through paradigmatic waves, which shows: (1) changing of perceptions (and their possible causes) from one wave to another (i.e., through the man, society and machine) and; (2) the value CST (one of the study's framework).

The complexion of this study (identifiable by complex/swap/messes/wicked phenomenon)'s problem situation warrants the application of CST. Critical systems thinking (CST), as the third wave (developed from the previous two waves) was remarked to be born from the context of overtly deal with: pluralism (mixture of systems methodologies) (Jackson and Keys, 1984:484); inclusive of the emancipatory tactics in interventions/systems. Accordingly, CST was elected as an pertinent wave (paradigm) for this the study, whilst Ulrich's concept of a system as a sum of conditioned realities [based on Kant (1781)'s transcendental ideas for partial comprehension of the totality (Jackson, 2003:217)]; was applied a methodological framework for understanding different conditioned realities (which is built on practical viewpoint as action-theoretical reference system and ST) through Koehler and Mishra (2005a)'s technological pedagogical content knowledge framework (TPACK).

The technological pedagogical content knowledge framework (TPACK)

Koehler and Mishra (2005a)'s TPACK was used to provide a theoretical base for the extension of the study's discourse on systemic thinking, with reference to technology, pedagogy and content (as conditioned realities), which are used to: (a) approximate their sum; (b) pragmatize the successive

sections. Only a small section of the discussion of TPACK is offered in this section, with the aim of revelling a bigger picture of the entire models/framework for technical adoption in educational settings.

The TPACK framework is remarked as a thinking perspective (Koehler and Mishra, 2005a:135; Mishra and Koehler, 2008:10), which is: (a) used to describe the understanding of the knowledge (which is conditioned) that teachers need to have in order to effectively use technology for teaching; (b) made up of intersection of the knowledge bases. Mishra and Koehler (2005c:2); Koehler et al. (2013:14) propose that these knowledge base include: the technological knowledge (TK); pedagogical knowledge (PK); and content knowledge (CK).

The TK is described as the 'fluency of information technology (FITness), which necessitates the aspirant to understand information technology (IT) to the degree of using it productively for communication/processing in his/her daily activities by: (1) differentiating when IT impedes/assists goal attainments; and (2) repeated adaption, (owing to IT vicissitudes) Koehler and Mishra (2009:64).

The PK is perceived, in this study in the mindfulness of the learning/teaching practices, processes, methods; which include recognition/understanding (Mishra and Koehler, 2008:5; Kurt, 2019), of: (1) educational values/aims/purposes (2) skills (i.e. lesson plan/implementation/assessments techniques) and any other classroom management actions in student's learning.

The CK in this study is proclaimed apropos of Koehler and Mishra (2005a); Cox and Graham (2009:63)'s suggestion, which embraces subject (independent from pedagogical representations, activities) taught/learned.

The intersection of TK, PK and CK was argued to produce knowledge, as well, in form of the technological pedagogical (Koehler and Mishra, 2009:65; Koehler *et al.*, 2013:16), pedagogical content (Koehler and Mishra, 2005a:132), technological content knowledge (Koehler and Mishra, 2009; Kurt, 2019) and (Mishra and Koehler, 2008:7) and TPACK (Mishra, 2019:76).

It was observed that TPACK components are volatile, owing to e.g. scenario/time. Cox and Graham (2009:64) observe that TCK transmutes to CK whereas TPK changes to PK as tools used in existing representations become transparent/mainstream.

TPACK PERSPECTIVES ON USING IM FOR TEACHING PROGRAMMING: GUIDELINE DEVELOPMENT

The previous section was used to offer the theoretical view of the conditioned realities of the study. This section is used to advance the practice, where the discourse on the study's technological (TK), pedagogical (PK) and content (CK) knowledge is suggested. The human computer interaction (HCI) and instant messaging (asserted as the occurrence of HCI); are submitted first as the TK of the study.

The study's Technological Knowledge: Human Computer Interaction (HCI) and Instant Messaging

In this section, two perspectives on the study's TK are tendered: the broad and narrow conditioned realities in relation to the TK of the study.

The broad conditioned realty of TK of the study

In this section, HCI is discoursed as a broad conditioned realty of TK, where broad 'conditioned reality' view of the initial guidelines is presented at the end. In this study HCI was regarded as a craft and science (Dix *et al.*, 2004:6); which holistically: (a) includes human, computer and interaction (as multiple perspectives) (Dix *et al.*, 2004:4; Thuseethan and Kuhanesan, 2015:2); (b) emphases on the physiological/psychological attributes of the relationship between computers and human (Dix *et al.*, 2004:xvii; Thuseethan and Kuhanesan, 2015:1).

The critical (re)view of the human(H), part of HCI in terms of physio/psychological aspects and their variances was used to shed light on their usefulness or not in the determination of a relationship between a human and a computer; i.e. it was argued in this study, as remarked by Dix *et al.* (2004:368) that human sight (though complex because of its physical/perceptual disparities) is the prime way of interaction (graphical, textual, and animation) as is employed by several persons. Accordingly, an understanding of e.g., perceptions (i.e., size and depth, brightness and colour, reading in terms of eyes) and critical mass should be considered

whenever designing/developing a computer in terms of HCI, because human's ability to perceive fine details (i.e., visual acuity) is unguaranteed.

The computer portion of HCI, was analysed in terms of broadening its original definition by i.e. Thuseethan and Kuhanesan (2015:3); Dix *et al.* (2004:4) to incorporate instant messaging applications, where instant messaging: (a) was argued to be a crucial application part of HCI; (b) application was observed as an interface as it can be used by humans (as an interface) to interchange with a computer (i.e., tablet, mobile phone, desktop iPad).

Designing theories (e.g., cognitive approach and activity theory), interface styles (i.e., command-line, menu, point and click) and their key attributes were also examined in this section, where a point and click was suggested as a fitting style for the study, since as reported by Dix *et al.* (2004:145), it supports windows, icons, menus, pointer interface; thereby affording touch screens interaction services to IM application, where it can be indirectly (e.g., shortcuts, mouse point and click,) or directly (e.g., via fingertip drag and drop, button tapping) manipulated.

The deliberation on interaction, as HCI element was also done, along the notions **like: (1)** interaction types e.g., batch processing, virtual reality and direct manipulation; (2) **interface design processes; (3) interaction enablers; (4) evaluation tools; and (5) design rules, where some principles were selected from literature.** A snapshot of the principles that were analysed and deduced as appropriate to this study are shown in Table 1.

Table 1: A synopsis of HCI principles categorized according to authors and publication dates

Category	**Principles according to:**
	Norman (1983:254-257)
N1: Consistency	*Consistency*: is viewed as the persistence in the system's structure and design so as to mitigate memory problems in getting needed operations.
	Molich and Nielsen (1990a:338-339)
MN1: Simplicity	*Natural and simple dialogue:* Avoid irrelevant or hardly required information as it competes with appropriate data. The 'natural format' assists in the eradication of possible barriers that can be caused by

	language, experience and concentration level (Dix *et al.,* 2004:366; Stone *et al.,* 2005:97).
MN2: Directness	*Minimization of user memory load*: User memory load is reduced when instructions/help is visible, easy to retrieve (whenever appropriate) so that users do not have to remember information from one portion of dialogue to another.
MN3:Consistency	*Consistency*: Consistency ensures that users are not confused with: (1) e.g., situations, words, actions, management between subsystems; (2) or forced to acquire new skills for any added feature (which operates the same with the current one) of a computer (Bunagan and El Kadhi, 2016:113).
MN4: Responsiveness	*Feedback provisions*: Feedback provisions is when updates are provided within reasonable time.
	Talin (1998)
T1: User profiling	*User profiling:* Focuses on knowing the users, their goals, needs, skills and experience. Actual end users can be given a computer; for user testing (to find inevitable defects).
T2: Humility	*Humility:* Consider opinions of users (especially ordinary, non-technical, novice) so that the computer can be used by even average users.
	Dix *et al.* (2004:261-273)
D1: Controllability	*Dialog initiative:* Dialog initiative is power given to a user (whenever possible) to initialize an interaction (user pre-emptive) so as to impose certain restrictions to a system.
SP2: Simplicity	*Short-term memory load*: Simple displays and consolidated multiple-page displays can be used to resolve/reduce memory problems.
	Stone *et al.* (2005:97)
S1: Clarity	*Visibility:* Visibility is vital in explicitly making clear, the purpose of an interface/control to a user.
S2: Simplicity	*Simplicity*: Complex tasks are made simple for better comprehension with simplicity.
	Galitz (2007:40-50)
G1: Clarity	*Clarity*: Clarity of interfaces involves the application of user-friendly visual concepts (simple and realistic metaphors/analogies), appearances and wording (natural/simple) which relates to a user's day to day functions and concepts. Clarity can be enhanced by usage

	of direct manipulation, provisions of one primary action per screen and keeping secondary actions secondary (Porter, 2013).
	Kalbach (2007:147-154)
K1: Simplicity	*Efficiency*: Visible and easy to use.
	Johnson (2008:7-48)
J1: User conformity	*Conformity to the users' view of the task*: User interfaces should be designed according to the point of view of the users (usually obtainable from requirement gathering and analysis stages).
	Porter (2013)
Po1: Clarity	*Clarity:* Enables people to see the advantages of using one computer over the other (Galitz, 2007:42).
Po2: Simplicity	*Smart organization reduces cognitive load*: S*implicity,* makes *many things appear as they are few and s*upports users to appreciate the interface more quickly and easier. A successful interface enables a user to focus on his/her own goals such that upon completion they are gratified and may not want to reflect on the situation.

In Table 1, the column first category, is utilised for branding the principles (e.g., D1, where D represents the author's surname i.e. Dix *et al.* (2004) and 1, a number for the variation). The branding process is vital for traceability when comes to the next table. The second column is utilised for the provision of the principles and their meaning.

The principles in Table 1 were analysed and thematically grouped and summarised in terms of H, C and I; as the broadest 'conditioned reality' picture of the initial HCI guidelines for using instant messaging in computing training, as shown in Table 2, where only a part of the main table related to this study is shown to demonstrate the process used.

Table 2: Preliminary HCI guidelines for using instant messaging in computing training

Proposed guidelines in terms of H of the human computer interaction		
Proposed guidelines in terms of H of the human computer interaction		**Principles from Table 1 represented by each of proposed principle**
H1	Humans' capability/limitation differences should be considered/capitalised on (since they influence computer usage and ultimately its adoption) in respect of:	

	i. Long-term (e.g., gender, culture, physical and experience/intellectual abilities). ii. Short-term (e.g., effects of stress, fatigue). iii. Changes through time (e.g., age, context).	T1: User profiling; J1: User conformity; T2: Humility.
Proposed guidelines in terms of C of the human computer interaction.		**Principles from Table 1**Error! Reference source not found. **represented by each of proposed principle**
C1	A computer should permit (usefulness with regards to its utility and usability qualities) users to achieve their expected tasks/goals with least effort and resources (not given additional problems such as diverting attention from their own goals and tasks).	MN1: Simplicity; SP2: Simplicity; S2: Simplicity; K1: Simplicity; Po2: Simplicity; Po1: Clarity; S1: Clarity; G1: Clarity; D1: Controllability; MN2: Directness; MN4: Responsiveness; S3: Universality.
Proposed guidelines in terms of I of the human computer interaction.		**Principles from Table 1 represented by each of proposed principle**
I1	Interfaces should conform to user's natural knowledge by: (a) hiding unwanted things (sophisticated/less frequently used commands, functions, or actions); (b) featuring prominently important functions (c) offering common, clues [i.e., sensible defaults, templates, progressive disclosure, 'canned' solutions, more attention for distinction (animated, coloured, bolded, italicised], signs (confirmations and warnings), and functions/values (initial stages).	T2: Humility; J1: User conformity; N1: Consistency; MN1: Simplicity; SP2: Simplicity; S2: Simplicity; Po2: Simplicity; K1: Simplicity; G1: Clarity; MN3:Consistency; MN2: Clarity; Po1: Clarity; S1: Clarity

A critical review of the principles shows that various researchers sometimes contribute to similar HCI principles although disparities in their captions and occasionally, a minor in their definitions exist. Thus, Table 2 is used to group the related principles, where the: (a) first column of the table is used for the labelling of the initial guidelines; (b) second column is used to depict the guidelines, which are a resultant from the critical assessment of the previous sub-sections with the key emphasis on the human, computer and interaction aspects of the HCI; and (c) last column is used to show the source of the guideline (i.e., obtainable from different principles from the previous table e.g., T1: User profiling; J1: User conformity; T2: Humility).

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A narrowed 'conditioned reality' view of the initial guidelines: A discourse of an instance of HCI

This section was used to debate on instant messaging (IM); an instance of HCI in relation to interface with the objective of affording an understanding which can be utilised to refine the developed guidelines, as regards to IM qualities.

Important reviews done on this section include the IM's: (a) definition, (b) motive for use; (c) types; (d) usage indicators in the South African context; (e) historical development of IM; structure (inclusive of organisations responsible for particular communication standards i.e., Internet engineering task force, protocols, cryptography mechanisms); (f) operability, (g) technological affordance and challenges. The theory gained from this discussion was used to enhance the previously developed guidelines.

Revised Technological (T of TPACK) guidelines

The previously developed guidelines were enhanced in this section through the application of IM notions, as shown by a snapshot in Table 3, where only a part of the whole information is shown.

The Table 3 is made up of six columns, the: (1) first two are a duplication of guidelines from the preceding table; (2) third, is used for reviewing the preliminary guidelines in terms of IM [where contents are in form of textual message and media (i.e. video documents, sound and pictures)]; (3) fourth and fifth are constituted of the reflections on the novel guidelines in relation to the text and media (respectively); (4) sixth, is utilised to offer comments to the corresponding guideline, in IM context

Table 3: The technological guidelines in terms of H, C, I and their reflections in instant messaging

Proposed guidelines in terms of H, C, I and their reflections in instant messaging					
Proposed guidelines in terms of H of the human computer interaction.		**Revised guideline based on IM for teaching**	**Impact on Text**	**Impact on Media**	**Comment**
H1	Humans' capability/limitation differences should be	H1.1 All materials	H1.T1: Apply H1.1	H1.M1. Apply	H2.T2: Students will be stressed if the

	considered/capitalised on (since they influence computer usage and ultimately its adoption) in respect of: i. Long-term (e.g., gender, culture, physical and experience/intellectual abilities). ii. Short-term (e.g., effects of stress, fatigue). iii. Changes through time (e.g., age, context).	should be sensitive to long-term human capabilities/limitations. H1.2 Student's short-term capabilities in terms of stress and fatigue should be taken into account in all material. H1.3 Material should cater for different competency levels of students and facilitate growth in competencies.	to all text to make provisions of gender, culture, physical and experience and intellectual abilities etc. H1.T2: Single messages should not be too long H1.T3: Text (e.g., composed, forwarded) should be contextually sensitive (i.e., time, age).	H1.T1 to all media. H1.M2: Media should be concise but complete. H1.M3: Apply H1.T3 to all media.	content they receive has "gaps" and they are unsure of how to react. H2.M3: Incomplete information causes stress. H2.T3: Students will experience fatigue if they receive too much unnecessary material. H2.M4. Students will experience fatigue and lose concentration when reading too long continuous text messages.
Proposed guidelines in terms of C of the human computer interaction.		**Revised guideline based on IM for teaching**	**Impact on Text**	**Impact on Media**	**Comment**
C1	A computer should permit (usefulness with regards to its utility and usability qualities) users to achieve their expected tasks/goals with least effort and resources (not given additional problems such as diverting attention from their own goals and tasks).	C1.1: Clear user-friendly and natural commands/controls/settings (for consistence) should be provided in IM applications for learners so to that they	C1.T1: Learners should be able to manipulate text effortlessly and effectively (i.e., quick reference, retrieval/recall, compose,	C1.M1: same as C1.T1.	C1.T2: Learners will get confused, annoyed and demotivated if utility provisions (e.g., advantageous, applicability, serviceability, and appropriateness) and usability (e.g., learnability, efficiency, memorability, satisfaction and

		accomplish (satisfaction) their tasks/goals with least effort, resources and time.	edit, delete, forward).		effectiveness*)* qualities are removed (thereby minimizing or removing IM social/practical acceptability) and replaced with vague commands/controls/settings. C1.M2 Students are unable to capitalise on already acquired media manipulation knowledge/skills to apply in same/comparable contexts, if media is not natural.
	Proposed guidelines in terms of I of the human computer interaction.	**Revised guideline based on IM for teaching**	**Impact on Text**	**Impact on media**	**Comment**
I1	Interfaces should conform to user's natural knowledge by: (a) hiding unwanted things (sophisticated/less frequently used commands, functions, or actions); (b) featuring prominently important functions (c) offering common, clues [i.e., sensible defaults, templates, progressive disclosure, 'canned' solutions, more attention for distinction (animated, coloured, bolded, italicised], signs (confirmations and warnings), and functions/values (initial stages).	I1.1: Consistence of materials in terms of what students are used to should always be considered.	I1.T1: Familiarity quality through e.g., expectations (affordances, signifiers, mapping, conceptual model) should always be used in the manipulation of text to assist users with the reduction on memory load.	I1.M1: same as I1.T1.	Students should not always be compiled to learn new commands or their representation (i.e., icons).

Proposed guidelines in terms of IM					
IM 1	The private/public sector should continue to invest (e.g., through provision of free access to certain hotspots, zero rated facilities, more bandwidth and any other subsidised costs) more in IM so as to reduce costs	Not applicable	IM4.T1: Text manipulation techniques should continuously be improved to enhance communication through support of both the private/public sector.	IM4.M1: Same as IM4.T1.	The use of IM in/out classroom environment may be affected of both private/public does not financially assist.

The review on the guidelines originally created from HCI ideas, according to the technical notions of IM are exhibited in Table 3, where novel guidelines; from: (1) the amalgamation of HCI and IM ideas, and (2) additional guidelines, strictly recognised from IM deliberations [not previously documented from HCI considerations (i.e., IM1)] are displayed; although not in any order. Dooyeweerd (1979)'s theory of aspects is therefore used in this study to group the guidelines; as shown in Table 4.

Table 4: Revised Technological (T of TPACK) guidelines

Revised Technology (T of TPACK) Guideline	**Revised guideline from combining HCI/IM enriched guidelines**	**Applied to text message**	**Applied to Media**	**Guideline from Table 3**

T1: Quantitative	Software development life cycle procedures (requirement gathering and analysis, design, implementation/coding, testing, deployment and maintenance) should be followed when developing an IM application so that a suitable artefact is produced.	Recommended software development means should be followed to ensure that text manipulation materials are in line with user's needs.	The development of media materials of IM should follow suggested procedures to cater for various options for e.g., ubiquitous, familiarity, universality, interoperability, control, substitutivity, customisability, observability. contextuality (needs, knowledge, experience, habits), visibility, fast feedback, complementary.	C8.1; I4.1.
T2: Spatial	Teachers/students should exploit the wide usage view of IM by the youths (due to perceive negligible/no cost, user-friendliness, presence/status update, multi-modality, temporal affordance, interoperability, immediacy, group formations and management affordances) and apply it in learning situations.	No further additions.	Educators should exploit the already wide use of IM by many people, especially the youth in terms of cost reduction [e.g., on mobile device, maintenance, connectivity (data), battery life, technical support.	H8.1

T15: Pistic/faith	Materials used in IM should be intuitive to flexibility where learners are given power to: (1) initialize an interaction (for e.g. control); (2) make more choices through multi-threading, platforms (i.e. mobile/desktop, Android and iOS), (3) find information (through rich guidance); (4) efficiently perform, integrate/apply skills learnt from other contexts; (5) customize (for e.g. interoperability); (6) substitute in/output representations (through i.e. shortcuts, value replacement, tapping, swiping or double clicking).	Learners should not be limited in their text manipulation endeavours through the provision of effortlessly and effectively (i.e., quick reference, guidance, retrieval/recall, compose, edit, delete, forward) easy, natural procedures.	Leaners should be able utilize various IM media with less effort through the provision of various options for e.g., ubiquitous, familiarity, universality, interoperability, control, substitutivity, customisability, observability. contextuality (needs, knowledge, experience, habits), visibility, fast feedback, complementary.	H4. 2, H4.3, I2.1, I5.1.

The Dooyeweerd (1979)'s theory of aspects is applied as an organisation tool in Table 4, where only a section the entire table of the study is displayed.

1.1 The pedagogical knowledge: Connectivism

This section was used to broaden assessments on the way teaching/learning takes place in computing thereby extending an arena for the dialogue of the study's 'conditioned realties, by appreciating and evaluating the study's pedagogical constrictions and affordances; which according to this study's assessment influences both content and technological knowledge. The gained pedagogical knowledge is applied to the guidelines developed from the previous section where emergent refined guidelines are obtained, in relation to the interrelationship between the pedagogical and technological understandings.

Notions discussed in this section include: (1) the learning models, as the philosophical base of the pedagogy; (2) connectivism in respect of its principles; and (3) the reflections on the interrelationship of the pedagogical and technological knowledge of the study.

Education was deliberated, in this study through learning theories; specifically Siemens (2008b)'s view of learning and categorisation (i.e. cognitivism, behaviourism, constructivism

and connectivism). A comparison of the characteristics of these learning theories was thematically done through e.g., learning occurrence in the general discipline; memory role; distinguished proponents, features influencing learning, transfer manifestation, suitable types of learning, perceived learning in programming terms, common methods used and (dis)advantages, where a decision to consider connectivism as an applicable model was made.

The connectivism epistemologies were implicitly discussed and applied in this study through a detailed review of Siemens (2004:4)'s connectivism principles; and some added in this study to compliment Siemens (2004:4)'s. These include: (a) openness for anytime, everywhere; (b) acknowledgement of messiness is critical; (c) autonomy is indispensable in connectivism; (d) creation and critiquing of a conducive learning environment is essential; (e) adoption of emerging phenomenon is central and (f) acknowledgement of messiness is critical.

The discussions of the principles, among other aspects was centred at highlighting expectations of an enabling learning environment, which were remarked to enhance learning/teaching. This includes the creation, maintaining [critiquing knowledge sources (e.g., in variety opinions, humans/non-humans), learning processes (inclusive of their worth)] and value of learning networks.

It was argued that tools/opportunities learning, should be cheering, imaginative, beneficial, interesting and pertinent to the student's real life. Some of the teaching/learning tools that were critically reviewed include: (a) learning management system; (b) mobile learning; (c) personal learning environments (d); learner centred approaches; and (e) personal learning networks. Notable instances on student centred approaches include inquiry learning, which were argued to be attained though interactive teaching styles (e.g., think pair, exit slips, buzz session, misconception check).

Technological pedagogical knowledge (TPK)

The conditioned realities of knowledge (as TPK) in this section were observed as dynamic due to their e.g., scenario/time and in consistency to one of TPACK's the traits. Accordingly, some of the observed affordances today (in TK/TPK terms) were argued to be limitations

The pedagogical affordances of these technologies were argued to be demonstrated by the students' views in relation to e.g.: comfortability, efficiency, flexibility and effectiveness and learning (Zhu *et al.*, 2016:1); as regards to (1) students' 'cognitive significances' (i.e. evaluation/tests performance) (So, 2016:34; Andújar-Vaca and Cruz-Martínez, 2017:64); (2) group/individual problem-solving capabilities (posting of intuitive observations on particular concepts) (Kim *et al.*, 2014:31; Tangb and Hew, 2017:95).

Some of the discoursed pedagogical affordances in this study include Tangb and Hew (2017:93)'s observations in IM (i.e. journaling, helpline, transmissive and assessment) as well as learning activity enablers, protracted dialogic space, databank, support to on-demand access, feedback, sharing and practical learning (as additional) were discoursed in this section.

Social affordances provided by the technology (IM), were also discussed in this section as it was argued that teaching/learning takes place in social settings, through informal channels e.g. affect through e.g. emoticons/stickers [by e.g. displaying user's feelings and nonverbal cues, (e.g. embarrassment, laughter, surprise) (Wang *et al.*, 2016:29)].

Educational/social challenges associated to the technology were also reviewed, where it was underlined that an improper thoughtful and application of TK results to challenges (Bonnah, 2015:9), i.e.: technophobia (Brosnan, 2002:13); and technostress (Çoklar *et al.*, 2016:1332). Some educational and social challenges discussed in this study include: (a) plagiarism; (b) furtherance of activities like sexting, gossiping and cyber-bullying; (c) unavailability of rules/framework to use and (d) addiction.

THE THEORY GAINED FROM THIS SECTION IS PRESENTED IN BRIEF, AS GUIDELINES, IN RELATION TO THE OBTAINED PK AND TPK UNDERSTANDINGS, AS SHOWN IN Table 5.

Table 5: Instant messaging guidelines in terms of pedagogical understandings

Expectation	**Description of the expectation**
	Guidelines related to PK
PK3: Autonomy	Instant messaging materials should in natural for the enhancement of autonomy so that a student is empowered (to take personal voluntary decisions/actions e.g.,

	creation of personal learning environments), responsible, accountable, self-govern, creative and independent.
	Guidelines associated to Technological pedagogical knowledge (TPK)
TPK1: Multi-modality	Students should be encouraged to use multi-modal forms for: i. knowledge dissemination sources [external (formed from networks) and internal (distributed across brains or residence in humans) and physical environments (non-humans or organization, database)] thereby giving students more prospects to concentrate on issues they believe to be valuable for their education or knowledge acquisition enhancement; ii. different content delivery (i.e., video, text, hyperlinks) to enable affective learning.

A snapshot of guidelines developed from the understandings of the study's PK and TPK is presented in Table 5. The first column is used to display the code of the guideline, which is vital for traceability, whilst the second column is used to display the guideline. The guidelines in Table 5 are used for reflection.

Table 6: Instant messaging enhanced guidelines in relation to the technological, pedagogical and technological pedagogical knowledge

Code	Revised guideline from combining TK and PK enriched guidelines	Guideline from Table 9	Guideline from Table 3	Reflections in text terms	Reflections in media terms
TPK1: Pistic/faith.	Instant messaging materials should be natural (e.g., customizable, interoperable) to enhance flexibility where students are empowered to be autonomy (in terms of accountability, self-govern, creativity and independent) to make decisions (i.e., control,	PK3: Autonomy.	T15: Pistic/faith.	Effortlessly and effectively (i.e., quick reference, guidance, retrieval/recall, compose, edit, delete, forward) easy, natural procedures needs to be provided for text manipulation to enhance students learning and	Instant messaging media facilities need to be natural so that they are familiar to and universally applied by leaners.

	content prosumers).			autonomy prospects.	

An enhancement of IM guidelines is shown in Table 6, where: (a) there is a continuous application of the Dooyeweerd (1979)'s theory of aspects to group the guidelines (b) guidelines developed from the previous section are reflected upon with the ones developed from this chapter, resulting to their enhancement with respect to the study's technological, pedagogical and technological pedagogical knowledge.

From the Table 6, the: (a) first column is used for codification of the guideline; (b) second is for the enhanced guideline in terms of TK and PK (reflections of third and fourth column); (c) third and fourth indicate the source of the guideline(s) reflected upon in second column; and (d) fifth and sixth column are used to reflect on the new guideline in terms on text and media respectively. A reflection on the table is offered later, in the paper.

The content knowledge: Computing programming

This section is used to assist in broadening reviews on conditioned realties of the study's specific content, the study's content knowledge (CK) where a critical evaluation is done on (1) association and effect of the obtainable content and technological tools, the technological content knowledge (TCK); and (2) the means some topics/issues are represented/organised/adapted to various setups (to match leaners' interests/abilities), the pedagogical content knowledge (PCK). As the form knowledge bases and their association, only a minor portion of available discussion is presented. The knowledge gained from this chapter is employed to the formerly developed guidelines (in technological and pedagogical terms) to generate a new set of enhanced guidelines, observed as the intersection (in technical terms) of the study's base knowledge, the TPACK.

A critical review of this section was centred on the study's: (a) CK background, as the section's reference point, where a contextualised gist of computing training was advanced inclusive of the explicit subject, taught to secondary school, computing learners, technical and vocational education and training students (b) TCK and PCK's relationship exploration.

The proposed guidelines are developed, initially, in the settings of computing pre-service teachers (as participants) for secondary schools and TVET colleges (for ethical reasons), but

the emphasis is on training programming to TVET student and secondary school learners. Thus, the study's CK, is offered in relation to programming at TVET and secondary school level (although a critical review, at the university position was also done for contextualisation). Thus, source documents like programming syllabuses, relevant textbooks, modules and policy [i.e. the South African curriculum and assessment policy statement and Practical assessment task (DBE_SA, 2019)] were critically reviewed.

A brief discussion of the study's CK (as Java topics and concepts), TCK and PCK (proposed activities) is shown in Table 7. Some of the Java topics (as the study's CK), appraised and summarised from source documents, though not incorporated in Table 7, include: an overview (of computer systems, basic programming terms), introduction to Java programming (objects/classes, statements, inheritance and polymorphism, exception handling, strings, data structure and algorithms), introduction to basic graphic user interface (i.e. Java desktop and database application programming).

Table 7: Programming content imparting at secondary school and TVET colleges, summarised from source documents

Topic	Programming Concept	Proposed activities
Exception types.	Exception (checked/unchecked, throwing, finally) (Paul and Harvey, 2012:438).	Instant messaging is utilised to: (a) apply any interactive approaches for participation; and (2) offer links to some eBooks with embedded videos, history (for accessed pages), interactive (e.g., permit users to edit and execute programs) capabilities.
Summary of the chapter.	The chapter is summarised by: (a) reviewing and applying basic concepts of exception handling through e.g. code reviews (Wilson, 2019a); (b) predict a behaviour of a displayed code (Wilson, 2019a); and creating an artefact, where students are given themes to considers and not question.	Instant messaging is used to provide themes in Java exceptions handling i.e., ArithmeticException, FileNotFoundException, IOException, students required to create a source code of their choice using various means i.e., adaptive electronic textbooks or eBooks or interactive interface/books such as Zyante, Runestone.

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The proposed activities, (Table 7) accomplished via instant messaging [the pertinent technological tool of imparting the content in relation to the TCK and PCK] are briefly accessible through the third column. A number of approaches, for imparting, intended tasks (submitted as a mixture or specific application of high/low/unplugged prospects) are briefly noted in the subsequent section.

The TCK of the study

The TCK was debated along the technological approaches/tools' capacity to impair/enhance programming learning in relation to their technological level of high/mid/low/no-tech. They were therefore contended to be barriers to teaching/learning if they were not more high-tech.

A review of some high/mid/low/no-tech approaches in this section showed that there were instances where they were: (a) contextually categorized due to (i.e., cost, experiences gained) differently by various literatures; (b) observed to overlap each other; thereby providing blur distinguishes. A researcher/teacher is therefore recommended to be mindful of these blur references to accommodate multiple views for diversity.

In this study sophistication and costs were suggested as some of a few determining features that could be used to group these tools/approaches (high/mid/low/no-tech) since the more: (1) effort spent on learning and costly (i.e., buying, maintenance) the tool is, the further 'high-tech' it is; and (2) conventional and inexpensive the tool is, the more mid/low/no-tech it becomes.

Some of the high-tech tools according to Blackburn-Dwyer (2016); include a computer, electronic devices i.e., smart projectors, smart boards and tablets. In this study, high-tech tools were argued to include: (a) mobile technology; (b) learning management systems (i.e., Blackboard), (c) intelligent tutoring systems; (d) visualization approaches and (e) video streaming.

The discussion of mid/low/no-tech was also centred on their characterisation i.e., affordances/limitation; where it was observed that some tools can be mid/low-tech, depending on the context [i.e., under certain agreements i.e., toll-free numbers, zero-rating websites and offline capabilities]. Accordingly, some notable tools discussed on mid-tech category include simple calculator; and electronic dictionary/speller.

Discoursed instances of low-tech tools include: (a) learning management systems (e.g., Kolibri); (b) mobile technology (c) prewritten source code, software libraries; (d) presentations through e.g., animations (e) live coding; (f) adaptive electronic textbooks training; and (g) audio tours/narration. In this study, no-tech tools were cited as: unplugged styles (i.e., game programming) to coding and some, as interactive teaching activities such as think pair.

The PCK of the study

The PCK of this thesis was deliberated as offered by Saeli *et al.* (2011:73), in relation to the: (1) purpose of training programming; (2) concepts taught; (3) common programming misconceptions/problems faced by students; and (4) way a topic is taught. It is significant to note that the conversation of this study's PCK is also traceable to Table 7.

The understandings (as conditioned realities) developed from the previous sections were utilised to develop guidelines in respect of the CK, TCK and PCK, as revealed in Table 8 (as a snapshot of the overall guidelines).

Table 8: Guidelines of the study developed from literature in relation to the study's content

Expectation	**Description of the expectation**
	Guideline in relation to content knowledge
CK1: Content taught	The content taught to the students should: i. be accurate, timely, stimulating, and relevant to the student's current and future needs; ii. expose students to the emerging phenomenon (i.e., open instructional models where learning outcomes are unrestricted) to permit students formulate their ideas on what and how to learn; iii. thought-provoking, where complex queries (e.g., is copying form another source learning?) are asked.
	Guideline in relation to technological content knowledge
CK2: Conducive/ safe/enabling environment.	A conducive/safe/enabling environment should be facilitated to promote/admit: i. some mid/low-tech opportunities (depending on the context i.e., connections to toll-free numbers, short message services; zero-rating websites, offline, open source and low data capabilities) to cater for: (a) each student's various abilities/backgrounds (engagement/collaborations;

	active participation, flexibility, customizability by providing a targeted support for e.g. students with flaws in English language or computing background skills, those with busy life schedules); (b) costs (i.e. cheap means of learning in resource inhibited contexts); (c) different problem-solving approaches; (d) learner scaffolding/engagements/collaborations; (e) to compliment text (i.e. relevant diagrams/images so as reduce cognitive load problem by allowing summarisation, optimisation, specialisation, interpretation); and (f) delivery and feedback (through e.g. spatial relationships as regards to visualisation) on learning activities since a human mind is perceived to be firmly visually positioned, where people creatively acquire information by systematically uncovering connections in pictures than through reading text; ii. no-tech or unplugged services (hands-on activities/games e.g. Robot Turtles, LEGO maze, Raspberry Pi, Hummingbird Robotics Kit) to: (a) assist school/learners who are unable to access high-tech approaches or without basic technological infrastructure (e.g. Internet, electricity, mobile devices, computers); (b) make sure that learning of coding is more interactive and less frightening; (c) promote notions like innovation/creativity, motivation, collaboration/communication, research/information flow, decision-taking, problem solving, critical/creative thinking, digital citizenship/technology usage as well as any other computational thinking (i.e., decomposition, pattern recognition/generalisation, abstraction, algorithmic thinking, data representation, logical thinking, evaluation and debugging) ability or social development skills.
	Guideline in relation to pedagogical content knowledge
PCK1: Programming training	Programming training should be informed by: (a) the rationale for teaching it [e.g., academic skills enhancement (i.e., problem solving, critical/creative/high-level/computational thinking and other cognitive learning skills) and continuous learning (i.e., digital citizenship)]; (b) concepts to be learned; (c) reflections on known programming challenges (i.e., lack of computational skills); and (d) the way to teach it (engagement, participative and active).

The guidelines shown in Table 8 are used to reflect on those previously developed from the study's TK and PK, for improvement as depicted in Table 9.

Table 9: TPACK guidelines

Code	Revised guideline from combining the base knowledge	Guideline from table 10	Guideline from table 12	Reflections in text terms	Reflections in media terms

TPACK 1: Pistic/faith.	Instant messaging materials should be natural and with low-tech capabilities (e.g., customizable, interoperable) to enhance flexibility and usage where students are empowered work autonomously (in terms of accountability, self-govern, creativity and independent) to make decisions (i.e., control, content prosumers).	CK2: Conducive/safe/enabling environment	TPK1: Pistic/faith	Not changed. Effortlessly and effectively (i.e., quick reference, guidance, retrieval/recall, compose, edit, delete, forward) easy, natural procedures needs to be provided for text manipulation to enhance students learning and autonomy prospects.	No changes. Instant messaging media facilities need to be natural so that they are familiar to and universally applied by leaners.
TPACK 2: Pistic/faith.	Programming training should be informed by: (a) the rationale for teaching it (b) concepts to be learned; (c) reflections on known programming challenges; and (d) the way to teach it	Not applicable	PCK1: Programming training	Text used in IM should enable programming learning where e.g., students are able to use: (a) abbreviations to quickly refer to academic content (as, participative, and active engagement); (b) text to express the cognitive learning skills.	Media content of IM need to e.g., motivate (through metamorphism, where emojis, pictures, videos are used for creative thinking, express sentiments e.g., not understanding a certain concept)

Final guidelines, developed from literature are exhibited in Table 9; a resulting knowledge attained primarily from the conditioned realties of the intersection of the study's technological, pedagogical, content knowledge, as the study's technological pedagogical

content knowledge framework guidelines. A reflection on the table is offered later, in the paper.

These literature-based guidelines are tested/verified; imperially, as they are used to contribute to the development of a framework for using IM in computing training in secondary schools, technical and vocational education and training colleges from a HCI principle and critical systems heuristics perspective, in the next study.

REFLECTIONS OF FMA AND PROCESS

A critical review of literature shows the complexity of the world in which we live in, inclusive of educational settings in particular. Traditional teaching approaches seems to conflict with today's millennium learners' expectations. The usage of technology in educational settings, seems not to have improved the educational standards either, because of the barriers such as the 'haves' and 'haves not': e.g., access to/not to the study content and environment. Even those, who have, they seem to have challenges with using them due to the lack of the knowledge on the means. For instance, older mobile phones are the only technology available to the students whose parents/guardians are low/no income earners, because of their capabilities (e.g., manageable costs and ubiquitous). As, observed in literature, although prospects of using mobile phones in education with applications like instant messaging exist; due to complexities (i.e., organizational; individual; micro, macro and meso forms); most millennium learners who have access to IM, do not use it for learning.

This paper therefore is used to provide a study that depicts a way to make a difference; to emancipate the affected/involved (students, teachers) in achieving the seemingly impossible: using IM for teaching in order to reach their full potential. Checkland and Holwell (1998:15)' FMA **framework played a significant role in this critical social research study. The employed methodology was very significant in the enlightenment of the condition of the problem area (computer programming) as well as suitability of e.g., human computer interaction (as the framework).**

A continuous review of 'learning about', enabled the enhancement of the guidelines as updates were continuously done, starting from the original guidelines (Table 3) to the final (Table 9). From Table 6, in reference to second column, it was noted that there are cases

where: (a) it does not change (if it is not impacted by the PK); (b) it has a totally new guideline (not previously included in the initial guidelines (from HCI and IM) but only derived from PK). There were cases, as well, when the fifth and sixth column remain unchanged (if no effect is observed on column two).

From the Table 9, in reference to second column, it was observed as well that there were cases where: (a) it does not change (if it is not impacted by the CK); (b) it has a totally new guideline (not previously included in the guidelines produced from TK and PK but only derived from CK). There were cases, as well, when fifth and sixth column remain unchanged, if no effect is observed on column two.

CONCLUSION

The motivation of the research team was to attempt to turn lemons (IM) into lemonade (learning platform). We conclude that it is possible to use IM as learning platform as long as it done in a considered way. This paper demonstrates what we mean with by a considered way. When using IM as learning platform we suggest from our guidelines that the practitioner focuses on the technological characteristics of the chosen IM platform from an HCI perspective. We showed how the principles for good HCI can be adapted to apply to IM platforms. We also argued that one should explicitly reflect on the pedagogical since the guidelines are meant for assisting in training. We argued that this pedagogical aim should be refined to suit a specific discipline. Accordingly, reflections of guidelines in relations to a specific subject produced contextualised guidelines that can be used to use IM in teaching programming. These literature-based guidelines are verified; empirically, through a participative action research process, in the next stage of this research.

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