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Social Justice to Learning Computer Programming: A Critical Systems Thinking Approach in Computing Education at a University

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Abstract
Numerous literature sources in computer programming education (CPE) have emphasized that learning programming is difficult. Several reasons are provided, which include subject complexity, student culture, technology integration, and institutional infrastructure. Several tools are proposed to remedy this situation, but the problem seems to persist. A critical systemic approach (CSA) is suggested in this study to alleviate these problems. Literature on the usage of a CSA in computing training environments is scarce. Utilization of the CSA permitted the researcher to apply a critical multi-methodology, where several interpretative data collection (diaries and online semi-structured interviews) and analysis (cross-case and collaborative) methods were employed. A purposive sampling technique was employed to select the study participants, namely five computing teacher trainees and two experts in critical systems thinking, human-computer interaction, computer science programming, and curriculum development. The computing teacher trainees collaborated with the initial data. At the same time, the experts contributed to the theory in the form of validation and provision of new insights that the teacher trainees overlooked. Some of the study results indicate that a more comprehensive stakeholder social contract is needed to remedy these problems. It was also observed that student profiling plays a significant role in computing learning and, if considered, would empower the computer instructor to accommodate student uniqueness. On the other hand, learner autonomy was considered critical as it empowers students to take ownership, take risks, continue learning, and critique learning.

Keywords: action research practice, community engagement, continuous learning, critique learning, social justice.

1.Introduction
Learning programming has been reported to be a problem. Some of the problems that are encountered in learning programming include individual attitude (Cheah, 2020, p. 3), subject complexity, institutional infrastructure, student culture, and technological incorporation (Poindexter, 2003, p. 2). Other significant challenges include those associated with problem-solving abilities (Cheah, 2020, p. 1; Mhashi &

Alakeel, 2013, p. 21; Saeli et al., 2011, p. 80), comprehension of programming knowledge, strategies, or skills (Khaleel et al., 2019, p. 152), and being too demanding (e.g., time-consuming) (Ericson et al., 2015, p. 1; Hooper et al., 2007, p. 1; Radošević et al., 2009, p. 50). Some programming tools (Cheah, 2020, p. 1) and approaches, such as simulations and robot programming, are suggested by some scholars as mitigators of some of the challenges faced in learning programming. Although they are good approaches, accessibility to these approaches or tools is a problem. The success of using robots, for instance, is limited to their availability (Kanika et al., 2020, p. 170), while with the usage of simulations, is asserted in this paper as a black box, where students need an accompanying explanatory theory. As a result, students are disempowered (as they rely on their lecturers as a source of knowledge) and deprived. Thus, it is argued that these solutions are peripheral, as they solve or mitigate small problems that are faced by students, while circumventing others. This paper argues for a stakeholder-holistic approach in resolving or mitigating programming challenges that are faced in computer science, so as to emancipate the students who are disadvantaged and enhance social justice. In this study, the view of social justice in relation to learning computer programming concerns academic empowerment and emancipation.

A multi-methodological approach was employed in this critical longitudinal study that is exploratory and participatory. Several interpretative data methods and approaches were utilized to critique and unearth challenges in the current computer programming environment, which were deemed to be disadvantageous in nature, with the aim of liberating the disadvantaged. This includes an approach called the organized use of the rational thought (FMA) model proposed by Checkland and Holwell (1998, p. 13) and Ulrich's systemic notions, especially critical systems heuristics (CSH). The theoretical underpinning of the study is provided next to set up its basis for discussion.

2. Research design and methodology

2.1 Theoretical underpinning of the study

Checkland and Holwell (1998, p. 13) organized use of the rational thought (FMA) model was applied as the study's theoretical framework. The application of the FMA model (Figure 1) as a research framework in this study was informed due to its perception that a specific type of data collection means, technique, tool, or methodology (M) is administered to explicit interrelated thoughts or a theoretical position (F) to critique the area of application (A).

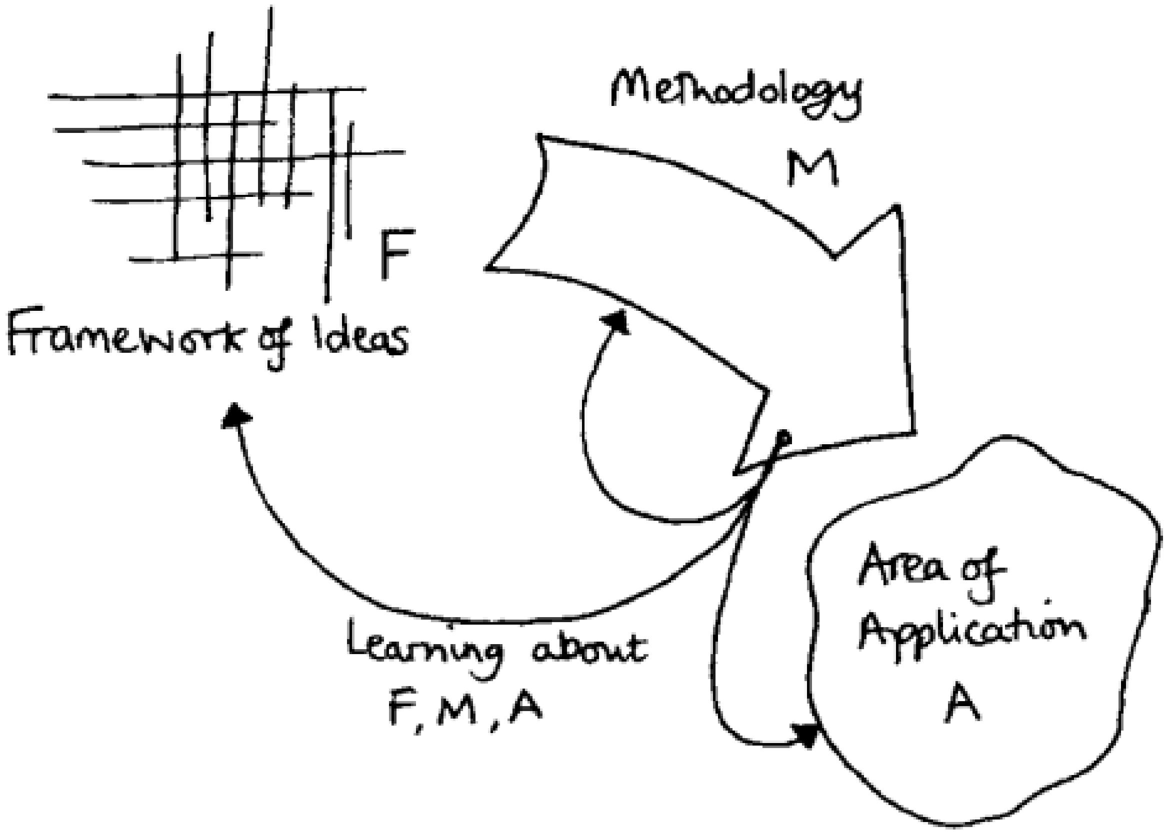

Figure 1: Checkland and Holwell's FMA model (Checkland & Holwell, 1998, p. 15)

The suitability of the FMA framework in this critical social research (i.e., its reflective practices which produce "conditioned realities" every time a cycle is done) is justified in that the usage of M (the critical methodology in this study) may educate stakeholders about the state of A and the appropriateness of F (Checkland & Holwell, 1998, p. 13). Eventually, learning is acquired through the FMA model in respect of the conception of the theoretical footing from which the action started (F), inclusive of the understanding of the stance from which the action was taken (M) and the advancement in A (West & Stansfield, 2001, p. 255). F is exploited to determine the compatibility and appropriateness of M (West & Stansfield, 2001, p. 268). F and M allow reflection of the action research (AR) phases, where changes are made accordingly, as depicted in Figure 1. This reflection permits the body of knowledge or theory to be contributed by an AR study, where findings are based on "action" at an applied problem situation (A), which can be traced back to the assumed M and F as the underpinning for the AR "study" (West & Stansfield, 2001, p. 275). An adjusted version of the FMA model shown in Figure 1 is presented in Figure 2, showing the F, M, and A components in relation to the current study.

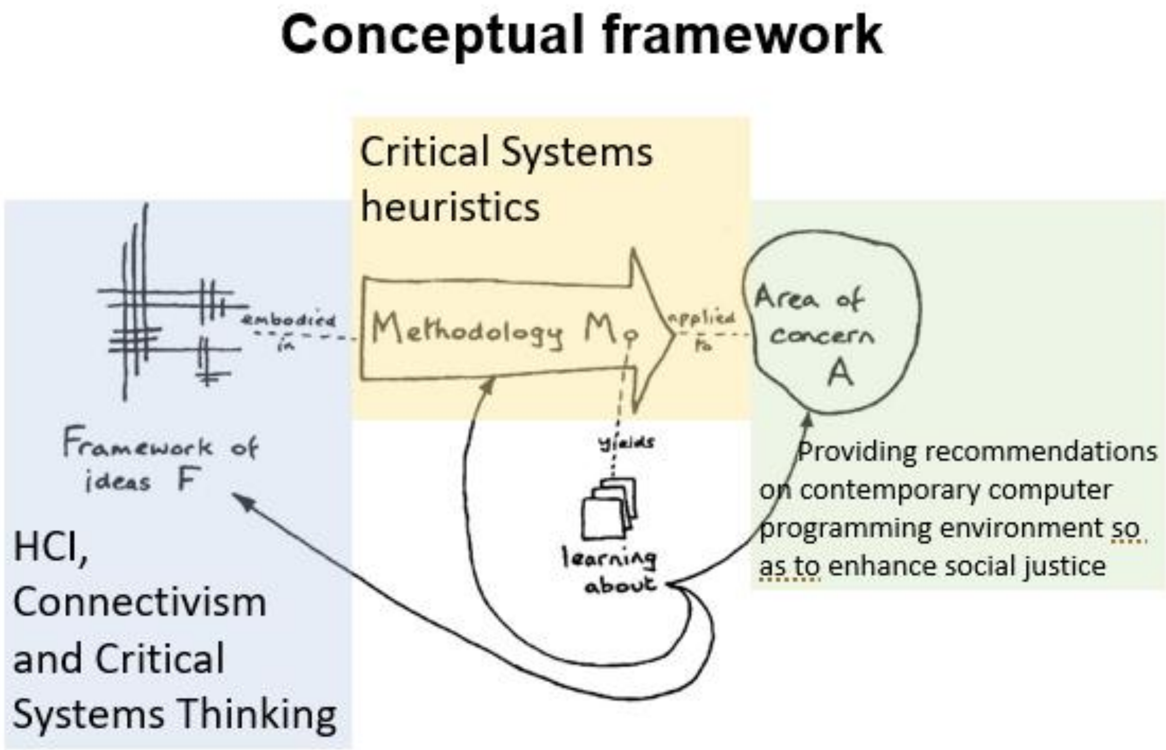

Figure 2: The modified Checkland and Holwell's FMA model of the paper (Checkland & Holwell, 1998, p. 15)

a. The F of the study

The F in this study consists of critical systems thinking (CST) and connectivism concepts. In this study, CST is admitted and utilized as a pluralistic systems thinking schema that uses a diversity of systems approaches (e.g., participatory) to examine and address local, uncertain, complex, impermanent, and imperfect problems and inform stakeholders on the best direction for its usage. Connectivism is regarded as a learning theory in this paper and is used to value how learning (computer programming) takes place, since, as debated by Kalelioglu and Gülbahar (2014, p. 34), some programming problems are ascribed to the teaching approaches. A detailed discussion of connectivism and other learning theories is not provided in this paper, although the concepts are acknowledged.

b. Methodology

A critical methodology guided by AR was utilized in this study, which was informed by several interpretative data methods and approaches. Different connotations of AR exist; for instance, AR is observed as a basic social inquiry technique or its sub-class (Baskerville, 1999, p. 6). In this study, AR is established as an iterative practice involving community stakeholders and researchers whose main duty is to recognize a problem, analyze it, and act on it (Foster-Fishman & Watson, 2010, p. 236). A detailed discussion of the AR processes is not provided in this paper, although they are acknowledged.

CSH is regarded as a CST methodology that is intended to assist stakeholders (i.e., researchers and participants) in dealing with a transparent understanding of the meaning, inevitability, and critical connotation of justified break-offs (Ulrich, 1989, p. 80). A detailed discourse of CSH is not provided in this study, although acknowledged. CSH was, however, employed in this study through its systemic thinking, the conditioned realities, on which two forms are provided: a checklist (Table 1) and its pragmatization. The checklist was used to provide the context of the study in terms of various complex components, including the participant types, beneficiaries of the study, and power relations, which are argued to be partial and thus constitute conditioned realities.

Table 1: Checklist of boundary judgments of a computer programming educational system employing CSH

BI	Social group or roles	Specific concerns or role	Key problems
The involved	1. Beneficiary or client	2. Purpose	3. Measure of improvement
	Primary client: Secondary school learners, technical and vocational education and training students. *Secondary client*: Pre-service computer science teachers or lecturers and any other teachers or students who may want to use technology in teaching.	Advancement and practical reflections (through, e.g., processes, plans, and actions of participants or researcher) on recommendations for emancipating the designated clients through CST.	Incorporates social justice or the emancipation of intended beneficiaries in terms of their active participation as evidenced by different aspects such as autonomous, continuous, and critique learning.
	4. Decision-maker	5. Resources	6. Decision environment
	University research ethics committee, researcher, pre-service computer science teachers, or lecturers (as participants).	Accessibility issues (e.g., bandwidth, electricity, participants' mobile devices), time, and any other learning and teaching materials (i.e., their studying units).	The (a) participants' socio-economic setup, for example, restricted facilities (i.e., contact time, learning management systems, computer laboratories, and study periods per module); (b) place where the research was done (i.e., university) through, for example, its ethical committee; and (c) learning or teaching settings (i.e., program's academic guidelines such as notional hours and credits

			inclusive of limited learning or teaching hours.
	7. Expert	8. Expertise	9. Guarantor and guarantee
	Participating students and other individuals who are specialists in CSH, computer science, and research.	Planning, team playing, researching, pedagogical, technological, and content skills, as well as any other appropriate theoretical knowledge on concepts such as CSH, competent citizenship, programming, designing, and curriculum development.	Specialist in technological, content, and pedagogical knowledge, which includes experts in CSH, computer science, and ethics (i.e., university ethical committee).
The affected	10. Witness	11. Emancipation	12. Worldview
	Pre-service computer science teachers and the researcher.	The study participants are pre-service computer science teachers attending the course but not directly participating in the study, inclusive of secondary school learners as well as technical and vocational education and training (TVET) college students.	The ideal worldview includes (a) the administration of conflicts of interest on the evolving perceptions between the association of the pedagogical, technological, content, and empirical work perspectives and (b) social justice evidenced by a beneficial learning environment such as an open system that encourages active participation and continuous learning.

The provided checklist in Table 1 was applied as a set of conditioned realities, where numerous issues such as environment, stakeholders, resources, and owners are considered. The admission and use of the conditioned realities fit well with the proposed critical social theory (as the paradigm) and the FMA framework, where systemic cyclic practice is done to reflect on the learnings together with the general AR process. The actual (is) and normative (ought) perspectives were employed to advance these various perspectives, where the *ought* question was answered before the *is*, as postulated by Reynolds (2007, p. 107).

The data collection methods utilized included semi-structured interpretive interviews and diaries. Cross-case and collaborative analysis were employed as data analysis tools. The recommendations by Cruzes et al. (2015, p. 1640) on conducting cross-case analysis and proposals for doing collaborative analysis (Cruzes et al., 2013, p. 7) were systematically followed in this study.

c. The A of the study

The A of the study is also argued to be made up of conditioned realities, where various perspectives in regard to the technological, pedagogical, content, and empirical work were critiqued. A detailed discussion of these perspectives is not provided in this paper.

2.2 Study research procedure

Purposive sampling was utilized in this study to select participants who were dynamic with regard to their skills, gender and age. Participants could exit and join the study at any time as it progressed. Iterative data collection and analysis methods were also employed to aid this multi-methodology. These data collection and analysis methods informed each other through AR, as evidenced by its cyclic nature. Some principles from Klein and Myers (1999, p. 72), Myers and Klein (2011, p. 24), Harvey (1990, p. 14), and Baskerville (1999, p. 18) were also utilized to enhance the rigor of the research activities.

Three repetitions of Baskerville's (1999, p. 14) five phases of AR, amended from the model by Susman et al. (1978, p. 588/ASQ), were utilized in this study, as another set of conditioned realities, to holistically critique and identify advantages and challenges associated with the current computing training environment. The first AR cycle was focused on analyzing the current programming environment with the in-service computing teachers and the researcher as participants. The second cycle involved the researcher and the in-service computing teachers to assess the processes, plans, and possible explanations of challenges learned from the initial cycle. The third AR cycle was meant to reflect on the results obtained from the previous iterations by the researcher with the invited experts. The experts (as shown in Table 1) consisted of individuals skilled in curriculum or instructional development, CSH, research, and computer science. These experts were instrumental in identifying any inadequacies in the discovered results, which were updated accordingly.

3. Results and Discussion

Learning computer programming has been observed to be a universal problem in the computer science field (Cheah, 2020, p. 1). Several reasons have been attributed to this problem (Khaleel et al., 2019, p. 153; Kuljis & Baldwin, 2000, p. 285; Lahtinen, 2006, p. 7; Mhashi & Alakeel, 2013, p. 15; Peng et al., 2017, p. 275; Radošević et al., 2009, p. 50). These problems, their causes, and some suggested solutions by various researchers are acknowledged in this paper. It is, however, argued that some of the proposed solutions are limited in that they exclude some learners in the programming learning process, who are the actual beneficiaries. Robot programming as a technique, for instance, may be critical in attracting students to computer programming, but its success is limited to the accessibility of robots. Therefore, the purpose of this study, as evidenced by the results, was to enhance social justice in learning computer programming through emancipating and empowering these perceived disadvantaged students. Some of the results that are admitted in this study in relation to the enhancement of social justice in computer training are discussed in this section.

3.1 Diversity of opinions

Often, students do not personally experience or acquire all the skills or knowledge critical for making crucial decisions (Duke et al., 2013, p. 7; Siemens, 2008a, p. 6). In this study, diversity of viewpoints is admitted as vital in supporting students to obtain the desired skills or knowledge. In this paper, various viewpoints are observed to come from several learning societies. A learning society is debated as a grouping of non-formal (i.e., internships), informal (i.e., family or community members), and formal (i.e., schools, universities colleges) components (Popescu, 2011, p. 2). Consistent with Siemens' (2006, p. 16) view, it is submitted in this paper that learning and knowledge are progressively gained from these several sources. This view is also supported by Participant_3, who observed that: "*I sometimes get my programming knowledge and skills from things I do every day*". They continued: "*my understanding of understanding the flow chat or uml was based on my daily activities, e.g., waking up, going to the university, and getting back to my hostel*." Participant_1 also noted that he learned "*a lot during*" his "*social gatherings with*" his "*peers*", as they "*usually discuss programming knowledge/skills over a cup of drink. Like this other day, all the things we discussed before the exam came in that exam, and I was very happy*". Learning is also acknowledged to exist in non-human applications, which include files, databases (fog, cloud, and edge computing bases), and organizations (Siemens, 2006, p. 5). Additionally, it is also admitted in this paper that knowledge can be obtained from procedures, which include information analytics such as Apple's iWatch facility (Utecht & Keller, 2019, p. 112). In this paper, it is therefore surmised that one should be conscious of (a) the incorporation of diversity by teachers (this includes learning from machines, i.e., artificial intelligence); (b) consequences with regard to students' independent learning; and (c) relation to the teachers' roles, such as student scaffolding or empowering, as critical prosumers (Utecht & Keller, 2019, p. 111).

3.2 Contextualization

Context is cited as one of the critical elements in this paper as it recognizes the individual's capabilities and, eventually, their learning needs. Accordingly, environments that embrace a student or learner's requirements, background, interests, and preferences should be advanced (Lee & Hannafin, 2016, p. 714; Veletsianos, 2016, p. 9; Zhu et al., 2016, p. 8). This assumption is supported by Participant_2, who professed that: "*I tend to enjoy working when the projects or activities that I am doing are personally meaningful, that is, if they cover my [global and local understandings] as well as being practically relevant.*" Participant_4 emphasized the importance of context by citing that: "*this other day, the lecturer provided an analogy of how an ATM works, starting from when the person inserts his/her banking card until he/she collects money, that is, if available.*" According to the participant, this made him "*understand the usage of if conditions, case statement, and iterations*" (i.e., for statement) more because the analogy used "*had operations that they did almost daily*".

3.3 Complexity management

Complexity can be explained in several ways (Reynolds & Holwell, 2010, p. 4). This phenomenon is distinguished by the association of higher numbers of people, interlocking aspects, severe implications, different appearances, direct control, and a lot of uncertainty (Reynolds & Holwell, 2010, p. 5). Complex situations come in the form of simple, complicated, or chaotic contexts (Stephens et al., 2018, p. 12). Complexity has benefits and challenges to a system (Johnson, 2006, p. 2). In this study, in alignment with other researchers, it is therefore suggested that ways that acknowledge and work with complexity should be offered to augment learning or knowledge opportunities so as to (a) prepare users (computing students) for any surprises in the teaching or learning environment (Veletsianos, 2016, p. 19) and (b) encourage the investigation or acknowledgement of association between accountability, evidence, and messiness (Veletsianos, 2016, p. 26). In this paper, networking, continuous learning, flexibility in decision-making, preparedness to be critiqued, adoption of emerging phenomena, and thinking in messier forms are some of the ways acknowledged to enhance the management of complexity. Networking, continuous learning, preparedness to be critiqued, and thinking in messier forms are discussed later in the paper. In this study, as proposed by Participant_3: "*the fact that technology keeps changing makes it more interesting to use it, especially for learning. I remember bringing and the usage of cell phone to school used to be prohibited; nowadays, lecturers communicate with us and post messages and notes via those phones in- and outside classroom environments with ease*." The "main idea", as affirmed by Participant_6, is "*to make sure that these gadgets are used and any other situations are managed. For example, we use our cell phones to log on to apps such as 'Microsoft account', a situation which can be difficult if both lecturers and students do not use them to take advantage of their classroom environment*".

3.4 Flexibility in decision-making

Flexibility in decision-making is submitted in this study as critical in complex management. Siemens (2005, p. 15) maintained that a correct answer now may be incorrect tomorrow, which is why decision-making should be strengthened by quick-changing information, where new information is rapidly included to produce fresh thinking. In this study, aspects such as current knowledge, openness, connectivity, continuous learning, autonomy, and emerging phenomena are ascribed as providers of a flexible decision-making process.

3.5 An emerging phenomenon

An emerging phenomenon is interpreted in this study as an event that is the result of an interconnection of independent factors that are habitually categorized by complex and intricate characteristics that are sometimes accompanied by both challenges and opportunities. The phenomenon can be classified under practices and technologies that are occasionally challenging to distinguish, explain, or utilize. They (the practices or technologies) are evolving tools (software, technology), innovations, advancements, concepts (pedagogies), or processes and mechanization with unfulfilled tendencies, unexpected implications, and potentially redundant or disruptive tendencies (Anderson, 2016, p. 46; Veletsianos, 2016, p. 52).

An emerging technology is surmised to incorporate artificial intelligence, the Internet of Things (IoT), generation networks (e.g., 5G), blockchain, serverless computing, robotics, 3D printing, biometrics, drones, and extended (virtual and mixed) reality (Chuah, 2018, p. 1; Kwok & Koh, 2020, p. 1; Marr, 2019). In an educational environment, emerging practices or tools include competency-based evaluations, micro-credentials, partnerships in public or private degree offerings, massive open online courses, and open educational resources (Glance et al., 2013; Veletsianos, 2016, p. 3), inclusive of automated grading and flipped classrooms (Veletsianos, 2016, p. 3). The emerging phenomenon is pivotal in this study as some of its advantages or challenges and recommendations are admitted. Explicitly, the participatory characteristic of emerging practices or technologies supports authentic learning via critical thinking (based on experience) and self-correction through methods such as expert awareness (Veletsianos, 2016, p. 76). Some recommendations aligned with the emerging phenomenon include (a) the capability to take out certain skills from mutual metaphors and more intricate ways of practicing or thinking (Veletsianos, 2016, p. 20); (b) examining emerging technologies or practices in relation to learners' performance (assessments and tasks), inclusive of their lifeworld, ecologies, and interaction complexities (Morrison, 2008, p. 25; Veletsianos, 2016, p. 27); and (c) recommending institutions to be innovative by eradicating all technical, pedagogical, and institutional barriers to learning (Siemens, 2008b, p. 8).

Thus, it is argued in this study that both teachers and students need to be exposed to emerging phenomena, where (a) learning outcomes are unhindered to allow students to express their ideas on what and how to learn (Veletsianos, 2016, p. 21); (b) learning is considered as evolving, while knowledge is considered to prevail in networks (Siemens, 2008b, p. 19); and (c) thought-provoking questions (e.g., Is copying from another person learning?) are asked (Veletsianos, 2016, p. 21).

3.6 Networking

In alignment with Utecht and Keller (2019, p. 114), the value of networks, that is, the Internet, is obtained "not" through "content", which is attainable through research, but via connections established with other individuals, which are used to augment just-in-time learning settings and real-time collaboration. Knowledge or learning prospects can be gained through a community of learning or knowledge practices (CLKP). Through CLKP, (a) individuals are given prospects to be interactive, active, and continue to create and transverse networks to sustain continuous learning (Veletsianos, 2016, p. 150); (b) learning is reciprocal, between experts and laypeople (Veletsianos, 2016, p. 67); and (c) the informal learning settings are maintained, as most learning occurs out of school (Meyer & Gent, 2016, p. 26; Veletsianos, 2016, p. 69). It is therefore remarked in this study that connections should be nurtured and maintained to enable continuous learning (Marhan, 2006, p. 214; Siemens, 2004, p. 4). Some elements that have been indicated to nurture and maintain connections include refocus, rebuild, and reinvent (Veletsianos, 2016, p. 73). According to Veletsianos (2016, p. 73), these elements are critical, especially to meet challenges presented by emerging technology or practices. Adaptive knowledge, self-organization, openness (future or external-oriented), and context are also added to the list in this study.

3.7 Acknowledgement of messiness

Messiness is considered by several sporadically opposing practices or tools (Lee & Hannafin, 2016, p. 712; Veletsianos, 2016, p. 22). These practices or tools include course design, communication styles, institutional politics, learner expectations, digital environments, educational philosophies, habits, and assumptions (Lee & Hannafin, 2016, p. 712; Veletsianos, 2016, p. 22). Nowadays, traditional information sources have changed, as anyone in society has access to the means to produce information, in contrast to the structured hierarchical era (Siemens, 2008b, p. 5). Presently, information growth goes beyond the capability of people and organizations to make sense of it and handle its profusion (Boyack, 2004, p. 5192; Siemens, 2008b, p. 7). Some sources of information are community resources, special interest organizations, multiple media (graphical, aural, and textual), and libraries (Bundy, 2004, p. 3). Additional sources comprise websites, blogs, wikis, file exchange programs, forums, and databases (Duke et al., 2013, p. 6; Kop & Hill, 2008, p. 7; Siemens, 2008a, p. 5).
The roles between expert or source of information and amateur (i.e., legitimacy, trust, authority, concerns) (Veletsianos, 2016, p. 65), author and audience (Veletsianos, 2016, p. 68), and educator and learner (Veletsianos, 2016, p. 69) are blurred. In agreement with the view of Siemens (2006, p. 9), this paper argues that some contemporary teachers are faced with challenges in expressing learning processes and contents with regard to the digital age. To support this assertion, Şahin (2012, p. 439) also postulated that contemporary teaching or learning circumstances are contrary to those envisioned for "old-style theories". These structured or hierarchical settings are unfavorable for informal learning, which is desired by learners (Siemens, 2008b, p. 5; Veletsianos, 2016, p. 69). For example, currently, most learners (millennials) are more technologically inclined than their lecturers or teachers (Top Hat, 2021; Veletsianos, 2016, p. 69). These learners grew up with technology and desire that learning materials be provided in similar technological conditions as those they are accustomed to (Farmer, 2003, p. 5; Kukulska-Hulme et al., 2011, p. 220). They therefore avert traditional approaches to learning (Baker & Inventado, 2014; Veletsianos, 2016, p. 83). Instead, these millennials prefer to (a) communicate their insights in brief constructs, (b) obtain information from a condensed source as compared to a voluminous book, and (c) access information anytime and anywhere (Shift, 2018).

Thus, it is argued in this study that messier approaches to thinking or practicing (Veletsianos, 2016, p. 20) should be promoted to augment the probabilities of learning. Thought-provoking, complex questions (such as – Is copying from another source learning?, as surmised by Participant_3), should be asked. In this study (as proposed by Participants 1, 3, and 5), consistent with Veletsianos' (2016, p. 73) view, it is submitted that this includes supporting the utilization of artifacts or aspects of other disciplines. These include (a) metaphors (Veletsianos, 2016, p. 20) and (b) a variation of philosophies arising from the contemporary reality, which can be applied to obtain means of knowing (Duke et al., 2013, p. 6; Siemens, 2008a, p. 5).

3.8 Creating and critiquing a learning environment

Various explanations are utilized to define learning environments. Reference is made to matters such as (a) technology, time, space, control (classroom and behavioral management), place, student motivation, teaching methods, interaction, and classroom structure (Özerem & Akkoyunlu, 2015, p. 64; Zhu et al., 2016, p. 11); (b) group- or individual-based format and (in)formal settings (Bouhnik & Deshen, 2014, p. 218); and (c) constraining or enabling environments (Ellström et al., 2008, p. 3). An "enabling" learning setting, as remarked by Ellström et al. (2008, p. 3), proposes working practices or conditions that advance a balance between the reproductive (adaptive) and developmental (critical). The analogy of an "enabling learning setting" by Siemens (2008b, p. 15) is assumed in this study. The analogy likens a learning setting to a studio where the (a) paintings or any other artifacts are developed in colleagues' presence and (b) the "master" is privileged to examine all students' conducts and recognize their innovations. Under these circumstances, students are privileged to learn by receiving small directions from their lecturers as well as comments and work from their peers (Siemens, 2008b, p. 16).

Environmental circumstances are uncontrolled, although some are predictable and influenceable, thereby empowering an individual to prepare (Gharajedaghi, 2011, p. 30). This notion consequently leads to an argument, in this study, that learning procedures or surroundings should continuously be critiqued for relevance or creativeness in terms of stimulation, accuracy, and timing. According to Participant_1, "*this should be done to augment continuous learning, where numerous viewpoints are obtained*". Learning or knowledge expectations can be attained through re-evaluation of ideas, where (a) data on learning procedures are collected for possible assessments and enhancement (Zhu et al., 2016, p. 13) and (b) complexity or messiness is explored in relation to accountability and evidence (Veletsianos, 2016, p. 26).

These learning surroundings, as submitted by this study, incorporate (a) interactive teaching styles (Chang et al., 2002, p. 1; Knapen, 2018), (b) a learner- or student-centered approach (Lee & Hannafin, 2016, p. 708), (c) bite-sized learning (Arshavskiy, 2020; Shift, 2018), (d) mobile learning (Criollo-C et al., 2018, p. 1; Hamilton et al., 2016, p. 2), (e) the learning management system (Coble, 2020; Watson & Watson, 2007, p. 28), (f) a group work strategy (Quigley, 2013), and (g) personal learning environments (Veletsianos, 2016, p. 120) or personal learning networks (Mackley, 2014). A detailed discourse of these learning environments is provided in other studies conducted by the researcher.

3.9 Continuous learning

The desire and aptitude to know more is crucial since the contemporary environment is competitive and keeps on fluctuating. The shrinking shelf-life of knowledge suggests that what is acceptable today may be inaccurate tomorrow (Siemens, 2005, p. 3; Utecht & Keller, 2019, p. 112). Nonstop learning should therefore be prioritized as it enables individuals and organizations to manage any changes, notable by uncertainty or opportunities (Hasan & Roy-Chowdhury, 2014, p. s426). Table 2 presents some of the elements that contribute to continuous learning.

Table 2: Cultures for continuous learning (Adapted from Hasan & Roy-Chowdhury, 2014, p. s431)

Notions to maintain or nurture connections	Brief discussions on ideas that are utilized to sustain connections
Organizational slack	A continuous learning culture can be boosted by capitalizing on resource slacks, which, among other factors, include funds availability, free information flow, time, promotions, tools or infrastructure, and unrestricted community resources. Learners can exploit zero-rating facilities, where certain websites or applications are accessed with no or very minimum data charges (McBurnie et al., 2020, p. 2).
Reward	Continuous learning can be enhanced through rewards (intrinsic), such as appreciating someone's ideas, support, and attention provision by both lecturers and peers. The rewards can also take the form of recognizing and encouraging innovativeness (i.e., delegating the idea generator to lead as a way of building commitment through ownership), praising accomplishments, and implementing suggestions.
Leadership	The practice of continuous learning can be furthered by management that (a) inspires motivational or visionary commitments (i.e., scaffold the formulation of objectives or aims) and (b) act as role models in facilitating information creation and dissemination.
Common goals	Teamwork can be exploited to advance everlasting learning, where shared goals and a sense of ownership and pride are upheld. People have a sense of pride and are ready to share vision, ownership, discoveries, recognition, and functional areas through teamwork. They are also capable of managing conflicts and interdependencies (consensus, mutual respect, and trust).
Belief in action	Through action, there is an emphasis on results, which guarantees that quality, deadlines, and commitments are met. Additionally, there is also an assurance of completing schedules, empowering people, hard work expectation, and appreciation, thus boosting a continuous learning culture.
Safe environment	An encouraging environment that underscores invention as a constituent of career development should be allowed through, for example, permitting individuals the opportunity to (a) experiment with ideas, to fail or make mistakes and not be punished, as well as (b) debate on ideas and assess the status quo, thus enhancing continuous learning.
Autonomy	The devolution of procedures guarantees that continuous learning takes place as individuals are empowered to be innovative, accountable, and risk-taking.

Notions to maintain or nurture connections	Brief discussions on ideas that are utilized to sustain connections
External orientation	Continuous learning can be encouraged by adapting or adopting other individuals' (including those outside a specific discipline) viewpoints and building associations with external stakeholders (for example, lecturers or students from other institutions) for openness.
Future orientation	Continuous learning can be stimulated by focusing on the future, that is, where (a) short- and term-long goals are set, (b) there is a desire for change and improvement, and (c) past events are considered as a learning curve.

Through continuous learning (Table 2), (a) an investigation of the past, current, or future teaching or learning activities is done to apprise policy or practice (Meyer & Gent, 2016, p. 29); (b) technological resolutions are compared to local situations and available resources (Meyer & Gent, 2016, p. 17); (c) educational institutions transform their old customs of doing things (i.e., policies and processes) and associate them with evolving values of knowing and learning (Veletsianos, 2016, p. 57); (d) the technological approach is continuously critiqued for best practice (Meyer & Gent, 2016, p. 25); and (e) change is prioritized and managed as the entity's key success factor for technological adoption (Meyer & Gent, 2016, p. 29). In this study, it is argued that continuous learning environments ensure that current knowledge is updated. In this study, current knowledge is acknowledged to be obtained from the recognition of problems, emerging phenomena, and complexity. Thus, there is a need for continuous learning, connectivity, openness, autonomy, and flexibility (e.g., in making decisions).

3.10 Openness

Openness in learning is characterized by flexible involvement, where a system is open to external input (Downes, 2012, p. 71; Siemens, 2006, p. 34). Using open teaching and learning concepts entails (a) resolving or minimizing universities' traditional concerns on research, teaching, and learning, as they become progressively supported and intertwined by personal learning network aptitudes, enhanced learning practices, and novel prospects (Veletsianos, 2016:159) and (b) empowering users through various possibilities of rethinking, or scholarship (Utecht & Keller, 2019, p. 111).

Downes (2012, p. 37) submitted three components of openness that are recognized in this study. Open courses and lecturers are also included in the list in this study. An open course is underlined by infinite (not ending), networked, self-directed learning and peer-centered values, which work on a dynamic principle where variations are done in harmony with societal and technological variability (Veletsianos, 2016, p. 160). An open lecturer or teacher concept supports a free or clear knowledge society where learners are allowed to review their knowledge connections, consumption, and production through a mutual progression of learning networks (Veletsianos, 2016, p. 148).

The types of openness listed above can be encouraged by the usage of approaches such as "copyleft content licenses" and non-registered participants, where an interaction (i.e., presenting or commenting on students' messages and blogs) is done (Veletsianos, 2016, p. 154). Some of the attributes of openness offered by this study, in harmony with the view of Hasan and Roy-Chowdhury (2014, p. s431), include lateral thinking encouragement, sharing, intellectual honesty, role changing, criticism or conflict expectance, and acceptance.

3.11 Autonomy

Autonomy incorporates conceptions of control, responsibility or ownership, choice, decisions, independent goal setting, and actions (Lee & Hannafin, 2016, p. 714; Tschofen & Mackness, 2012, p. 128). In this study, autonomy is viewed in terms of Ryan and Deci's (2000, p. 712) "self-determination" theory. Self-determination theory observes aspects such as empowerment (sovereignty), volition, engagement, responsibility, persistence, creativity, and performance (Lee, 2011, p. 37). In this study, autonomy is also expressed as a vehicle to (a) self-govern, including the expression or will to take voluntary actions or personal decisions with room to receive help when needed (Downes, 2012, p. 439; Lee & Hannafin, 2016, p. 715) and (b) augment the procedure of learning to learn. Learning to learn challenges individuals to be creative and critical, experiment with ideas, and take risks (Ahmed et al., 1999, p. s427). An autonomy model by Downes (2012, p. 445), which includes issues that influence epistemic states (e.g., reasoning, cognitive, and experience) and the capability to act on epistemic states (i.e., social, physical, and structural), is acknowledged in this study.

4. Conclusions

The purpose of this study was to determine ways to relieve computing training students, who were perceived to be disadvantaged by the current training and teaching environment. A critical systems approach was utilized to address the study problem due to its nature. This included the utilization of some approach(es) to systematically unearth any issue(s) surrounding the study phenomenon, with the view that all methods, methodologies, or approaches are partial, where some groups are served less than others. This view of partiality was admitted as conditioned realities, which was the essence of the study. These conditioned realities were eventually explored to advance a close certainty to "holism", the "sum of conditioned realities". Different approaches were therefore employed to obtain these various partialities or conditioned realities and, ultimately, their sum. Some of the suggestions proposed in this study to enable social justice in computer science training or learning, which is ultimately perceived to emancipate the students, include diversity of opinions, contextualization, complexity management, emerging phenomena, networking, acknowledgment of messiness, creating and critiquing a learning environment, continuous learning, openness, autonomy, and motivation. Proposals were therefore put forward in the study in the form of expectations from all stakeholders with special reference to responding to the continuously changing needs of the environment in education.

4.1 Limitations and recommendations

This study is limited in that it was carried out at a university with students who are training to be computer science teachers or lecturers, due to ethical reasons. The actual beneficiaries of this study are secondary school learners and TVET college students. The study is therefore limited in that it was not applied to the actual beneficiaries. A more comprehensive inclusion of participants is therefore required.

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