How to Assess Reflective Writing in Computer Science Education? A Critical Analysis

Conference or Workshop Item

How to Assess Reflective Writing in Computer Science Education? A Critical Analysis

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***Abstract* - Reflective writing is important in higher education that supports students to improve their critical thinking. However, Despite the widespread of using reflective writing in education, there is a lack of literature relating to the important aspects of reflection in computer science (CS) education. This study approached to (a) address theoretically how reflective writing can be in CS (b) investigate theoretically the conceptual reflective writing framework (RWF) indicators in CS. The literature showed that the RWF's indicators is theoretically sound that the use of specific indicator can be less or more important based on the goal and the context of writing reflectivity. Finally, we consider the implications of refection aspects writing can be customized assessment to students based on the field.**

Keywords* - *computer science; reflective writing; assessment; higher education; reflection.

I. INTRODUCTION

Reflective writing is an important part of the learning process as experienced in professional education because it enables students to express and record their thoughts concerning their specific experience; this will assist them in improving their skills and understandings. However, despite the desirability of using reflective writing in education, the use of such reflection is lack of information on how the reflection in STEM* disciplines is [1-4]? that can be different from other fields. For this, it is essential to investigate what is the reflection in STEM disciplines in particular CS.

The findings of this paper offer insights into the nature of CS education's reflection. To answer the research question: how can reflective writing be different in CS education to another discipline?

We answered this research question by reviewing the reflection framework then focusing on one field (CS education). By comparing an empirical CS reflective writing framework with another framework in terms of the indicators (description of an experience, feelings, understanding, reasoning, perspective, future action, and new learning) and how can those indicators be used in another framework.

In the following sections, literature review presents the reflection in general and CS education, discusses the theoretical reflection. Afterwards, in Section 'Reflection indicators in CS education', we illustrated the reflection framework according to Alrashidi et al. [5] to link of the seven indicators with the existing reflection framework. Finally, we discussed the literature on how different reflective writing framework can be.

II. LITERATURE REVIEW

Many disciplines have used the existing frameworks for evaluating the reflection of learners across various fields, and the results of the empirical studies show the success of such applications.

This paper presents literature to investigate the different fields of reflective writing framework on assessment. This article identified 349 articles that are relevant to the topic of reflective writing in education. Upon scanning the abstracts and the context of the 349 articles, ordered by relevant, then narrowed the scope down to 33 relevant articles.

*STEM is a common abbreviation for four closely connected areas of study: science, technology, engineering and mathematics.

A. *Reflection in General*

Over the years, the reflection was shown to be significant, which encourage researchers from various fields to apply reflection to assess their students' thinking skills, purposing of assessing or teaching reflection or can be both. For example, in the field of nursing [6] conducted an experimental study that showed the effects of reflection on the critical thinking of nursing students. Chan [7] conducted a review that found evidence, albeit limited, on the positive effects of engaging in reflection on the skills of undergraduate nursing students in terms of their ability to learn from practice. Indeed, the use of reflection in nursing education has been studied extensively, and a comprehensive review on reflection in nursing education was presented by [8]. In medicine, Misra-Hebert [9] showed the potential value of using reflection in medical education. For physicians, Moallem [10] showed that engagement in reflection enhances empathy among practising physicians. Other studies have also been conducted concerning other fields, such as the field of design [11], mathematics [12], language teaching [13], and social work [14]. Overall, the benefits of reflection are enormous [15] since the potential of learning may be lost or forgotten if reflection on a topic or experience is not carried out.

Hatton and Smith [16] selected the framework that was proposed by Scanlan and Chernomas [17] without supporting his choice by the use of any evidence or logical argument. Nevertheless, the selected framework was employed to evaluate the reflection skills of the dental therapy students as they participated in a particular technique aimed at reflection encouragement; this used a structured worksheet activity called A Learning Experience (ALE). Pee et al., [15] taught and evaluated the reflection of nursing students in order to promote active thinking, using [18] framework for teaching and [19] framework for evaluation. Ballard [20] selected framework based on a set of supporting evidence.

The first attempt at a comparison between the two contexts (data science and pharmacy) was conducted by [21]. They presented a theoretical reflection framework based on five factors associated with student Capability for Written Reflection (CWRef); these were capability in terms of — written reflection, understanding of context, feelings, challenges, and changes. These capabilities were all used as metrics to assess students' reflective thinking. They applied CWRef in two specific contexts: pharmacy and data science. They found that 'the five-factor model was more suitable for the pharmacy dataset than it was for the data science dataset in terms of convergent validity and factor reliability' (p.14). This difference can be attributed to the learning designs and the task descriptions involved [21].

B. *Reflection in CS Education*

1) *Assessing Reflection for CS Education*

Recent studies in CS education have shown that the existing research regarding reflective writing is constrained to the use of existing reflection frameworks [2, 3]; these are not tailored for application to CS. In addition, these theoretical frameworks have not shown the reliability or validity results when applied in the CS context.

Demmans Epp et al., [1] claimed that 'reflection in scientific disciplines may be different in type to the type of reflections made in humanities because of the nature of the underlying knowledge'(p.79). Chng [3] study also indicated that it is necessary to teach problem-solving and reasoning skills in the course of CS education to improve students' awareness of how to learn from a situation they are presented with – such as how to deal with finding the right sequence of steps to reach a goal or how to identify the roots of a problem and not be led astray by their initial feelings about the situation. According to Boud et al., [22] reflection is a complex process that is affected by many real-life conditions and initiated by various metacognitive activities. Accordingly, reflection is also affected by the learning activities initiated by the learners. In CS, various activities necessitate the application of the common reflection processes, such as judgment, evaluation, reasoning, problem-solving, and memorizing [23].

2) *Reflection Frameworks in CS Education*

Writing reflectively is complex due to the introspective nature of the task and the aspects of writing based on one's experience. Previous research used different approaches to assess reflective writing in CS such as modified Kolb [24] as experiential learning [3], or a set of questions based on previous frameworks [2].

Moreover, there has been a lack of empirical effort directed at assessing students' reflective writings based on an appropriate framework. However, Chng [3] implemented a framework of reflective writing for CS education based on [24] by combining Kolb's experiential learning components with concepts related to the problem-solving process. Four 'actions' were defined: active experimentation, gaining experience, observation/reflection, and abstraction/conceptualization. In contrast, the Chng [3] framework focused on how the student should reflect by defining a series of processes. Kolb's framework is considered to represent a hierarchy process of learning that involves many stages [24].

Demmans Epp et al., [2] investigated reflective writing in CS education by asking students to write reflectively based on a set of questions relating to reflection and referring the student to examples of reflective thinking, in line with [25, 26], and [27]. They recommended investigating new methods, in terms of timing and coding schemes, to support the student to reflect usefully concerning CS education [2].

The challenge of reflection in the scientific field, the underlying knowledge represented in reflection is procedural, and this involves problem-solving. Accordingly, science requires awareness of one's capabilities in terms of actions leading to tangible outcomes rather than of one's feelings during an experience. This applies in CS education, whereas reflection regarding how to react and feel in a given situation is more applicable to medical education [28]. Demmans Epp et al., [1] recommended that further research should be undertaken to investigate the use of the reflective journal and reflective practice in CS education. More recently, Chng [2] recommended that 'further studies need to keep investigating new approaches in terms of timing, guidelines, and supportive tools to promote reflective

writing to determine which activity designs facilitate student improvement.

The recent study of reflective writing in CS by Alrashidi et al., [5] is the first study that developed the reflective writing framework (RWF) to assess the reflection's text for CS students based on the recommendation of CS instructors in higher education who have experience on evaluated reflection. The RWF is empirically evaluated by CS instructors and empirically evaluated by assessing students reflective writing then measuring the reliability between the assessors of that written text to reach a substantial agreement. This article discusses the key substantive findings from Alrashidi et al., [5] in particular, the seven indicators in the RWF framework from a literature perspective.

III. Reflection indicators in CS education

This study discusses the reflection indicators of reflective writing derived from the first attempt to investigate how the reflection in the CS field by Alrashidi et al., [5] study that investigated reflective writing with CS educators in higher education.

In general, a set of the seven indicators of the Alrashidi et al., [5] study was determined as common in the existing frameworks; these are the description of an experience, feelings, understanding, reasoning, perspective, future action, and new learning.

A. Description of an experience

The description of an experience indicator is greatly influenced by the area, goal, form, and type of reflection. Some frameworks are built by a general form of the description, and some are more specific. Such variation affects the naming and specification of the description of an experience indicator in the created framework. An early framework of reflection by Sparks-Langer et al., [29] used a description of the events as the form of non-reflective writing and elaborated on the description of experience indicators with the description of the events or its explanation. Hatton and Smith [17] associated the description of an experience indicator with the second level in the reflection framework, which was broadly defined as the attempts to provide reasons or judgment based on personal view or reviewed literature. This description of an experience label does not match the common definition of description; it is more likely to be understanding or perspective. Moreover, the first level, which is concerned about technical rationality in the framework, does not also match the specification of the description of an experience indicator. This description of an experience indicator does not concern reflection; thus, this indicator is not incorporated in all frameworks.

Sumsion and Fleet [30] framework and similar other frameworks [19, 21, 31-35] depend on the classical framework (e.g., non-reflection, reflection and critical reflection) and its variations. These frameworks which depend on some other earlier frameworks of Boud et al. (1985) and LaBoskey (1994), associated description specification with the non-reflective level [22, 36]. Williams et al. (2002) used the description of an experience learning indicator as a specialized form of the common description of an experience indicator[37]. Boenink et al. (2004) used the label 'oversimplified' to describe the description of an experience indicator, as this indicator does not include any perspective, as this study linked reflection closely with perspective, the better the perspective series is, the deeper the reflection is [38]. Accordingly, the oversimplified label indirectly reports descriptive action without further elaboration.

Similarly, Kember et al., [39] used the habitual action indicator in the proposed framework as a form of description, and it was defined as the answer for a question without an understanding of the concept or the theory. Plack et al., implicitly involved description in the knowledge and comprehensive levels that represent the non-reflective level in the classical frameworks [40]. Boutet et al., [41] also implicitly used description in the pre-reflective level of the developed framework as it was addressed as being able to identify strengths and weaknesses, which include understanding and feelings. Wong et al., [42] used description as a part of the criteria to distinguish between three levels, non-reflector, reflector, and critically reflector. The description of experience indicators was not addressed implicitly. Instead, the three indicators, which are association, integration, and validation, depending on the description aspect. Gibson et al., [43] does not involve this indicator, but the description can be somehow presented in the trigger level of the framework, as it is the pre-reflection step.

B. Understanding

The understanding indicator is closely related to description, as the description depends significantly on the understanding of the described matter. The understanding indicator is essential to any framework as it is the core of the reflection process. Understanding requires the cognition process that forms the core of metacognition in the high reflection process. Accordingly, understanding is mostly indirectly involved in the exiting reflection frameworks.

Classical frameworks [30, 31, 34, 36, 44-48] do not include understanding in the involved indicator. However, some can be argued to be indirectly using an 'understanding' indicator, such as the work of Ullmann (2019) that has an 'experience' indicator.

Kember et al., [39] proposed a modified classical framework that includes 'understanding' using the labelled indicator 'thoughtful' that is categorized under a non-reflective level. Similarly, Boenink et al., [38] framework used the indicators 'balance and contextualization' for this purpose Plack et al., [40] directly refer to 'understanding' at the 'knowledge and comprehensive' level Kember et al., [39] framework used the 'understanding' indicator in the developed framework. Lai and Calandra [49] the framework used 'routine' that is described to be an analysis and understanding of the situation. Similarly, the monitoring level in Gibson et al. (2016)'s framework refers to the learner thinking consciously about the internal and external process. Finally, the frameworks [28] that have descriptive to a critique of beliefs and habitual action, with the descriptive reflection [50] and Cui et al., [33] with analysis including 'understanding' .

C. Feelings

The feelings indicator is of explicit and independent nature compared to the overlapping nature of the description and understanding indicators. According to Sparks-Langer et al., [29] that the feeling is more about thought rather than emotions, for example, in this stage, the writer requires to describe why they thought it was successful or unsuccessful. This is in line with our findings in the CS.

The feelings presented in the frameworks [20, 21, 28, 34, 42, 48, 51, 52] using the labels 'Technical rationality, 'Attending to feelings', 'Attending to emotions', 'Experience as it was related to emotional contributions', and the latter three with 'Feelings', respectively. Besides, the feelings indicator is indirectly represented in the frameworks [41, 53].

The feelings is greatly influenced by the variation in the frameworks based on the considered reflection type. Some frameworks that focus only on the technical aspects might not include feelings, as emotions can be referred back to experience and analysis.

D. Reasoning

The reasoning indicator is common in the existing reflection frameworks. Reasoning, according to Hatton and Smith [17] is about weighing competing claims and viewpoints and then exploring alternative solutions. Larrivee [54] pedagogical reflection' levels are about thinking and continuous improvement with evidence. Moreover, reasoning with previous practices and social ethics is addressed as a critical reflection in Larrivee [54] framework. The reasoning presented in the frameworks [17, 28, 29, 31, 33, 37, 38, 42, 48, 50, 55-58] use the labels 'Explanation from theory', 'Dialogic reflection', 'Association indicator and integration indicator', 'Verifies learning', 'perspectives, general as well as personal', 'Reevaluate', 'Analysis', 'Dialogic reflection', 'Reflection on experience', 'Description of conflict', 'Dialogical reflection', 'Challenge', 'Analysis' and 'Process reflective', respectively.

The reasoning indicator is indirectly represented in the frameworks of Tsangaridou and O'Sullivan [59] which used 'Description & Justification' to represent the process beyond understanding into analysis with a rational and logical explanation. Chamoso and Cáceres [60] used argumentation that is referred to as 'justifies or draws conclusions about the learning process justifies or draws conclusions about the learning process'.

E. Perspective

The perspective indicator is the core of the reflection framework, as it is mostly the sole indicator of the critical reflective levels. A learner who expresses their perspective synthesizes and evaluates situations or learned topics is considered at a critical reflective level. In the recent frameworks by Cui et al., [33] and Ullmann [34] the perspective indicator was included as a unique indicator for critical reflection level. In the existing frameworks, Van Manen [20] considered perspective in the critical reflection level, Sparks-Langer et al., [29] indirectly considered perspective in the explanation from theory with the contextualization level, Hatton and Smith [17] considered perspective in the critical reflection level. Gibson et al., [48] Self-Critique indicator is about perspective. While Jung and Wise [35, 61] describes perspectives in more general for the pharmacy field as a consideration of others in terms of situation, feelings, needs or intentions.

F. New Learning

The new learning indicator was addressed by Sumsion and Fleet [30] in the highly reflective level, Williams et al., [37] used gains a new understanding category to represent new learning. Kember et al., [19] involved new learning in the critical reflection level, Lai and Calandra [49] transformative indicator involved new learning and change of perspective explicitly. Wong et al., [42] addressed new learning through appropriation making owns new knowledge, Mena-Marcos et al., [50] addressed new learning through the critical reflection level, Gibson et al., [48] addressed new learning through the learning opportunities category. Ullmann [34] addressed new learning through the reflection level. Similarly, Chamoso and Cáceres [60] contribution category and Cui et al., [33] evaluation and the outcome are indirectly related to new learning.

G. Future Action

The purpose of the reflection is to inform future actions in such a way that they can be more objective and intentional. The future action greatly depends on the area and the field of the reflection framework; accordingly, it should be presented mostly in writing that is expected to have such an indicator. Earlier frameworks are about developing reflection that contributes to enhancing future action but did not address those actions as a part of the developed frameworks. Accordingly, the future action indicator was not indicated in most of the existing frameworks, except for the framework by Williams et al., [37] that indicates the future behaviours as an indication for the developed framework. Wong et al., [42] used outcome to indicate future action explicitly, Fund et al., [45] 'critical reflection' address about future work, Chamoso and Cáceres [60] contribution indicator and Mena-Marcos et al., [50] critical reflection level address future action.

Some frameworks describe the new learning and future action indicators in a more general manner in one category, for example, 'the extent to which individuals feel they learned from their experience, and how it may shape their future plans/behaviour' (page 4) in one category named 'changes' [21]. Jung and Wise [61] also describe this indicator in one category 'outcome' as 'Students describe lessons learned from the experience or future intentions made based on experience' (page 7). However, the new learning and future actions are an important aspect in reflection as in CS the CS instructors want to see the students show both sides so in assessing reflection texts the students need to show the lessons have learned and the future actions for a similar situation in a positive way.

IV. Discussion

The increased use of reflective writing in higher education has led to an interest in the investigating of the

indicator used to assess reflective writing produced within CS education and this is the rationale for conducting an exploratory investigation of CS focused reflective writing aimed at obtaining a deeper understanding of how the professional skills of CS students develop in the specific field.

We found that the lack of empirical study of reflection framework might lead to creating a new reflection framework. We conclude findings that the reflection framework can be different in terms of many aspects such as evidence, levels, and context. This study focused on the evidence (indicators), which can be different from one discipline to another depending on the purpose of the writing.

In conclusion, the discussed indicators are presented in most of the existing frameworks, either explicitly or implicitly, some indicators are missing from some frameworks as the framework depends on the field and form of the reflection, and some frameworks combined multiple items in one indicator based on some similarity; thus, these indicators are presented indirectly in such frameworks. The framework that was developed by Wong et al., [42] and the modification that is presented by Kember [19] with the understanding indicator is used in the proposed framework for evaluating final year projects in the CS field.

Most frameworks look for evidence of a description of an experience in a writing. The description of an experience can be used as an introduction to the reflective writing topic that usually starts to describe the situation in an abstract manner does not take any effort to analyse.

Most frameworks mention understanding indicators directly or indirectly way which underlines the importance of this indicator in reflective writing. This indicator contains many critical thinking skills such as identifying problems, questioning, and analysis. This indicator can be seen in non-reflective and reflective levels depending on how deep is understandable of the situation. Framework' levels generally claim that if given writing is the description of an experience only, for example, it only states facts such as showing a summary of the experience, it is usually classified on the lower level known as non-reflective or descriptive level.

Feelings of reflection is evident in many frameworks. Feelings can be seen in a more complicated manner for example some frameworks focus on emotions others focus on the thought. this table illustrates both holistic perspectives of thoughts and emotions negative or positive.

The frameworks mention indicator reasoning which emphasizes the importance of writing. This indicator includes several thinking skills such as solving problems, questioning, analysis/justification, interpretation, appraisal, and decision making. This indicator is known as analysis, evaluation, and critical stance in some frameworks. The reasoning is important for the interpretation of action to make a deep understanding of the specific experience.

The outcome of a reflection is evident in many frameworks, several types of outcomes can be as perspective, new learning, and future action depending on framework purposes. For example, some frameworks require a significant change of perspective or behaviour, learning new things, or intention to do something. To achieve one of these that will need a deep understanding of the situation to confirm the critical thinking manner of the situation. It is also notable that rare to see quite a several frameworks have seen these indicators while the recent frameworks can be seen all of these indicators on one framework.

V. Conclusion

This article answered research question which has discussed the finding reflection indicators of conceptual RWF, describing the establishment of the framework through a review of the literature. That provided an investigation of the criteria for reflective writing used the CS educators (experts) in the CS field. We linked the conceptual RWF in terms of seven indicators with the existing reflection framework. We found that there are common indicators utilized on most of the framework. This can highlight the relationship between the reflection indicators and the CS field.

This conceptual RWF' contribution can be used not only as a guideline to assess reflective writing to support student feedback also it can be employed to fill gaps in the literature regarding CS education. This conceptual RWF may be seen as one of the first attempts to fill the research gap relating to the assessment of reflective writing within the STEM in particular CS education context.

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