Educators' Validation on a Reflective Writing Framework (RWF) for Assessing Reflective Writing in Computer Science Education

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Abstract. The need for effective Intelligent Tutoring Systems (ITSs) and automated assessment is increasing. One area of ITSs has become urgent is that of the automated assessment of reflective writing. The reflective writing has been promoted, in higher education, in order to encourage students to think critically about their learning. However, many frameworks have been developed for assessing student's reflective writing. Up to our knowledge, there is no empirical studies to validate reflective writing frameworks that used in Computer Science (CS) education. This paper presents the validation of reflective Writing Framework (RWF) by CS educators. The expert panelists validated the RWF. Subsequently, we proposed an ITS model for automating reflective writing analysis. The RWF was accepted that it received a level of consensus from the experts who reported obtaining from good to appropriate results using it.

Keywords: Reflection, Reflective writing, Computer Science, Assessment.

1 Introduction

Reflective writing is an important skill that helps learners to deepen their knowledge by gaining insights into their personal learning experience [1]. The use of Intelligent Tutoring Systems (ITSs) would enhance the process of reflective writing, as such a system could provide specific, detailed, feedback for each student [2]. The focus of this research is on reflective writing in Computer Science (CS) education. In terms of this, Fekete et al. [3], stated that "reflection is worth encouraging, for its indirect effect on the technical skills and knowledge which are our ultimate purpose in teaching Computer Science." Reflection improve students' awareness of how to learn from situations: e.g., how to deal with a sequence of steps required to reach a certain goal or how to identify the roots of problems rather than concentrate on their feelings about them [4]. Teaching technical skills may be difficult for some as it requires the possession, by the teacher, of a wide variety of technical, computing skills to deliver the concepts effectively. Reflection may be different from one discipline to another in terms of task-purposing. George [5] believes 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). However, in science, the underlying knowledge which is the subject of reflection is procedural and involves problem-solving. This requires, primarily, an awareness of one's capabilities in terms of actions that have tangible outcomes rather than an awareness of how one feels in the course of an experience, or, as in medical education, how one should react and feel in a given situation. Koole et al. [6] suggested that reflective writing needs further investigation using new approaches, involving perhaps the construction of guidelines and the analysis of the timings of the students' reflections in relation to computing topics. Basically, it is essential to have a valid framework for the assessment of reflective writing, based on the actual reflective processes involved. The wider aim of this study is to build an ITS that uses currently employed assessment criteria. This paper makes two-fold contributions: (a) the validation of this RWF by a panel of experts - phase two; and (b) the proposal of an ITS model for automating reflective writing analysis.

Related work

Reflective writing in CS education has been investigated in [3, 5, 7, 8]. However, the literature on reflective writing in CS education is still limited [3]. George [5] and Fekete et al. [3] focused on discovering the benefits of journaling to computing undergraduate students. These studies concluded that reflective journaling is useful for the students as they would reflect on the software development processes that they had learned about. Journaling can be done daily or weekly throughout a course.

Some studies have been focused on increasing the benefits of reflective writing. For instance, Stone and Madigan [7] discussed the benefits of reflective writing as "experiential learning activities for students that allow for enhanced learning outcomes" - using case studies. However, reflecting effectively and independently with no outside guidance can be a challenge for some students. Demmans Epp et al. [3] investigated the quality of student reflective writing and peer feedback in the CS education context. The quality of student reflective writing did not increase, particularly, once peer feedback had been applied; this may be due to the level of students' reflective abilities generally. Recent studies have confirmed that reflective writing in CS education is a topic crying out for further investigation focused on new approaches designed to meet CS education needs [3, 9]. More recently, Demmans Epp et al. [3] 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." Accordingly, up to our knowledge there is no framework have been empirically validated for CS education. In this paper, we will focus on empirically validation the adapted Alrashidi et al. [10] framework for reflective writing (see 2.1 section) that was developed specifically for CS education by CS educators.

2 Method and Results

A content validity survey was designed and applied in order to evaluate the RWF [10]. The survey was tested and reviewed by five independent researchers, all with a knowledge of CS, and/or in the theory of reflection. But first we had to select a group of experts. Participants had to have had experience of reflective writing and formative assessment, plus a background in CS education. Fifteen experts were invited to participate via email: five experts from higher education agreed to participate: two from the USA, one from Malaysia, one from UK, and one from Qatar. Our expert panel and their comments were maintained as anonymous (to each other as well). Lynn [11] argued for a minimum of three experts. Each of the experts on the panel was asked to rank each indicator and its associated reflective level. For the quantitative analysis, the method employed was that described by Polit et al. [12]; this uses a Content Validity Index (CVI) to evaluate the relevance of the questions to the study context; this index can also be used to indicate where and how improvements can be made. The calculation of CVI involves the combination of the following quantitative measures: 1): the Item Content Validity Index (I-CVI); and 2) a modified kappa (k) statistic to correct the possibility of chance agreement between the experts. The RWF reached a level of consensus such that only two I-CVI were obtained, 0.8 and 1 , and only two k statistic values, 0.76 and 1. These values indicate appropriate [12] and substantial agreement [13] respectively, see Table 1.

Table 1. Calculation of I-CVIs and k on Experts Ratings for Reflection levels and indicators

Items	Relevant (rating 3 or4)	Non-relevant (rating 1 or 2)	I-CVIs	k	Interpretations
Non-Reflective	5	0	1	1	Appropriate
Reflective	5	0	1	1	Appropriate
Critically Reflective	5	0	1	1	Appropriate
Descriptive	4	1	0.8	0.76	Appropriate
Understanding	4	1	0.8	0.76	Appropriate
Feelings	4	1	1	1	Appropriate
Reasoning	5	0	1	1	Appropriate
Perspective	5	0	1	1	Appropriate
New Learning	4	1	0.8	0.76	Appropriate
Future Action	4	1	0.8	0.76	Appropriate

3 The RWF

In order to define the RWF [10] which identifies the levels of reflection exhibited by CS focused reflective writings, a set of indicators (distinguishing between reflective levels) is valid. These became the core of the RWF. The framework is consistent the levels defined by Wong et al. [14] and the reflection indicators defined by

Ullmann [15]. The RWF employs three levels and seven reflection indicators. These indicators are: descriptive, understanding, feelings, reasoning, perspective, new learning, and future action. These refer to the three reflection levels: non-reflective, reflective, and critically reflective, see table 2.

Table 2 The RWF with descriptions of reflection levels and indicators adapted from [10]

Reflection levels	Indicators
*Non-Reflective *Reflective *Critically-Reflective	Descriptive: the writer reports facts from experience and/or materials Understanding: the writer understands and analyses experiences. Feelings: the writer identifies and analyses their own thoughts and feelings. Reasoning: the writer explains the experiences by giving reasons. Perspective: the writer shows awareness of alternatives. New learning: the writer integrates and describes new learning Future action: the writer intends to do something and plans for future action.

The *non-reflective writing level* is characterized by the mere description of things, like events or theories; such description will not be elaborated in terms of how, why or impact [14]. Text at this level provides answers to specific questions without further deliberation. In CS, this level applies when an existing technique is employed, or a theory is used without reference to the issues it raises, and without the forming of a view about it. The providing of previously determined definitions and attributes/properties; and the listing out of procedural steps, etc., without any demonstration of in-depth understanding, are the core attributes of this level (in CS). The following is a fragment/sentence of non-reflective writing from the CS dataset including only superficial **descriptive** text. “PhotoDoc is an application used to help the user organize the photo library in their personal computer.” (63, A,1)

The *reflective writing level* is demonstrated when the writer mulls over reasons, discusses alternatives, presents conjectures and exhibits other products of deep cognition [14]. The writer to demonstrates that they have added value to their acquired knowledge. Technically, this level concerns the relating or analyzing of concepts and theories in view of other knowledge or concepts. It is involved with providing relations between differing topics and between theory and practice and discussions about such linkages. In CS, according to George [5], this level occurs in relation to problem–solving and reasoning, and when theory is applied to a practical problem, and the linkage between these is provided. Here is a fragment/sentence from the CS dataset in which the presence of the **understanding** and **reasoning** indicators can be detected: “The issues that this caused later on in the project is that although I still had a good understanding of how the project was going to work, I did not necessarily understand the scope of some of the components” (51, B,2)

Writing at the *critically reflective writing level* exhibits new ideas and decision making. This level is involved with providing the type of transformations of perspective that are unlikely to occur frequently, and often relate to modifications to a fundamental theory. In CS, this level occurs when decisions are made, and conclusions are drawn using basic concepts. Here is a fragment/sentence of critically reflective writing from the CS dataset in which the writer provides evidence indicating his/her

new learning, **perspective,** and **reasoning**. These are the indicators for this level: "My planning skills have improved as a result of it and I was able to apply techniques I had learnt in previous smaller projects to a large project, such as creating an activity-on-node diagram as a way of visualising the schedule and identifying the critical path, and conducting a risk analysis procedure to identify risks to the project and a suitable mitigation strategy for each."(69,C,3)

The RWF describes seven reflection indicators. The presence of the '**descriptive' indicator,** only, indicates writing at the non-reflective level. For the '**understanding' indicator** to be present, the writer is expected to demonstrate their understanding of the experience under discussion. Sometimes the indicator is present falsely, in that the writer is depending for the expression of an understanding on materials and/or lecture notes. Thus, in this case, the indicator points to the non-reflective level. The **feeling indicator** suggests that the writer has demonstrated their own thoughts, feelings, and/or behaviors. The existence of this indicator promotes the idea that writers should understand and express their emotions regarding issue that arise. The **reasoning indicator** emerges when an in-depth analysis is made which leads to a significant conclusion. The existence of this indicator may motivate writers to recognize what is expected of them in terms of reflectivity and where their current practice is lacking.

The **perspective indicator** emerges when the writer shows awareness of alternative perspectives. The writer shows their awareness of their own and of others' perspectives and theories. This aspect led to the development of an indicator that focuses on the consideration of alternative perspectives rather than focusing on the changing of perspectives. The perspective indicator is an essential component of reflective assessment. It reveals that the writer refers to external perspectives including, possibly, other students' perspectives. The **new learning indicator** emerges when the writer describes what they have learned from an experience. As this is a critically reflective level indicator, to be said to have triggered this, writers will be expected to have provided a brief description of their new understanding of a situation or event. The **future action indicator** suggests that the writer would, given the same circumstances again, intentionally do something differently or they would form a plan of action based on the new understanding that has resulted from considering and reviewing the original experience.

4 The RWF for building Intelligent Tutoring Systems

There is no one-to-one mapping (between indicators and levels) which can support a reflective writing assessment. Accordingly, there is a need to develop a sophisticated mapping approach in order to reach the intended goal of automated reflective writing assessment. The approach proposed here to such a mapping depends on intermediating the classification between the reflection' indicators and the reflection levels, as illustrated in Figure 1.

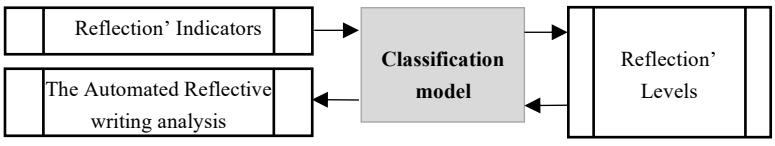

Figure 1. The ITS model for Automating Reflective Writing Analysis

Neither the reflection levels nor the reflection indicators can be mapped into the automated reflective writing analysis directly. The classification model is an intermediary that can categorize the content representing the reflection indicators to the reflection's levels because the classification model has been mapped into the automated reflective writing analysis.

5 Discussion and Conclusion

Using the expert questionnaire, the RWF was validated which included the reflection levels and indicators. These were compatible with the framework used by Wong et al. [14] in terms of reflection levels. In Wong et al. [14] study, three reflection levels were employed for categorizing the level of reflective writing produced by students; this structure could not be applied directly to our data. This is because three levels are not sufficient for categorizing the procedures of reflective thinking as they are actually found in the field [16]. In the case of the reflection indicator, Ullmann [15] indicators were found to be consistent with the indicators yielded in our results. This is possibly due to the fact that Ullmann used a most common indicators used in 24 reflections' framework. However, for this study, Ullmann [15] model was not used, for the following reasons. First, only two levels were employed in that study, reflective and non-reflective, whereas for this study, three levels have been defined. Secondly, Ullmann [15] applies indicator dimensions that are not compatible with CS education. Thus, our RWF defines its own three levels and seven indicators. These definitions should allow educators to support a content analysis on CS reflective writings. The advantages of this framework include helping educators to improve the feedback they give to their students' reflective writing and providing students with useful guidance materials so that they can become aware of the reflective levels appropriate for reaching their desired goals. This in turn will aid the experts to evaluate and distinguish between the students' reflective levels in a fair way. The proposed ITS model is wider in scope than it needs to be; this model should be more concrete so that it can form the basis of the implementation of the automated reflective writing assessment system. In future studies, we aim to automate the framework by implementing the ITS. This enable automated feedback on reflective writing by employing rule-based and machine learning algorithms to determine the features of reflective writing samples. This would represent a significant challenge, especially in terms of how to produce quality feedback automatically.

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