Part 1: a Literature Review of an aspect of Subject Pedagogy in Computer Science – Formative Assessment

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# Introduction

This literature review will be analysing and discussing how formative assessment has and can be used in the computing classroom to provide effective assessment for learning. This study will not be covering assessment of learning, or summative assessment, such as exams and coursework which is a separate topic.

Identifying useful forms of formative assessment is key in ensuring that the methods of teaching in the classroom are effective. Having effective methods for discovering if the students have fully comprehended new material allows teachers to better tailor their teaching methods to ensure maximum knowledge retention in their students. For this to happen, the methods used in formative assessment tasks need to provide the teacher with enough information to know which areas of their teaching strategy to modify. Numerous methods of formative assessment exist to benefit this purpose. Many of them are tried and tested, traditional methods that can be implemented regardless of the specific classroom they are used in. There are many more modern methods of formative assessment that can benefit explicitly from being used in a computing classroom as opposed to more analogue environments. This review will assess how effective these modern methods are at providing the same, or perhaps even greater detail that can be used to tailor teaching strategies in specifically the computing classroom.

Due to the more modern nature of some of the formative assessment methods being analysed, the sources used for this review will be mostly within the last 5 years of research. This is to ensure that there is as much evidence of the application of the methods as possible to provide an accurate and scientific analysis of the differences between these methods and the more traditional methods.

This literature review should give some insight on the benefits of using both traditional, and more modern methods of formative assessment within the computing classroom.

# Literature Review

## Traditional Assessment Methods

Traditionally, formative assessment has been carried out using many different methods, many of which have proven to be very effective at improving student’s performance in summative assessments.

Babincakova, *et al* (2020) carried out a recent study confirming this theory by using different “Formative Assessment Classroom Techniques” (FACTs). These FACTs were used with one group of 7th grade students while another control group of 7th grade students received no formative assessment during the same time period. The study group were taught using simple FACTs, these were: vocabulary squares, K-W-L charts, exit cards, checklists, true or false statements and concept maps. The result of this study showed that the scores achieved on summative assessment tasks by the study group were higher than that of the control group, and that this difference was statistically significant. This proves the usefulness of formative assessment techniques in improving students learning in the classroom. This study used basic methods of formative assessment, with all of the methods employed being quick, usually plenary activities. These methods were used to supplement the learning activities in the lessons, though there are methods of including assessment methods into existing learning activities.

Computer Science Education (Sentance, et al., 2018) goes into the details of a few of these more integrated methods of assessment. One method they focus on in particular is the use of self and peer assessment as methods of providing feedback to students on learning exercises. This traditional method of formative assessment gets the students to evaluate their own, and each other’s work. This is an effective method as it allows the students to look for areas where they can improve their work without the teacher needing to get directly involved. Encouraging this learning mindset is important for creating effective learners (Boud, *et al.,* 2013 as cited in Sentance, et al., 2018). Also mentioned is the use of Rubrics, which Sentence *et al.,* (2018) recommends are paired with the use of self and peer assessment to assist the students in evaluating their work. Rubrics give the students the details of what is expected of the work they have completed and allows them to evaluate which areas they need to improve in to achieve higher grades. These once again encourage the reflective mindset that is key in creating an effective learning environment for students.

Both Babincakova, *et al* (2020) and Sentence, *et al* (2018) agree that the use of formative assessment vastly improves the learning capabilities of the students they are used with. This emphasis on assessment for learning is echoed by Spector, *et al* (2016) who recommends that professional development opportunities need to develop the understanding of the role of formative assessment. This agrees with the previous literature and reinforces their findings that formative assessment is a key tool in creating effective learners.

## Modern Assessment Methods

With the addition of more technology to the classroom, especially the computing classroom, numerous new methods of formative assessment have appeared to make use of this technology. A few of these have appeared in many different discipline classrooms through the use of mobile devices. One common example of this is Kahoot (2020) which is an online quiz platform that can be used to facilitate formative assessment. The Kahoot quiz can be filled with diagnostic questions to allow the teacher to see how well the class is understanding a topic. Similarly, a system like Plickers (2020) can be used in any classroom by using QR codes to receive student responses to a quiz of diagnostic questions. These methods do not rely on complicated technology so can be used in any classroom via mobile devices. There are some new methods that are only able to be integrated into the computing classroom.

Mentioned briefly in Computer Science Education (Sentance, et al., 2018) is the use of automated tools for assessing students work. This is also investigated by Schute & Rahimi (2016) who delve into the research surrounding Computer Based Assessment for Learning (CBAfL). They look at a history of these automated tools and how the feedback produced by these tools has drastically improved since their introduction to the classroom. There are some tasks, such as programming assessment, where these automated assessment tools provide feedback that is just as comprehensive and useful as that of the teacher. However, the issue with these methods is that the feedback has to be designed for the students receiving it. This is so that the students actually use it rather than ignoring it (Maier *et al.,* 2016 as cited in Schute & Rahimi, 2016).

Spector *et al.,* (2016)mentions that these new methods of formative assessment will be unable to realize their potential if they are not used effectively to encourage students to want to learn. This is stating that the feedback, although valuable, will not be effective if the students are not motivated to follow it. So the issue being raised is that these automated forms of assessment are not engaging enough for the students to gain any meaningful learning benefit from them.

The solution to this problem may lie in the gamification of these feedback mechanisms. Wang *et al.,* (2016) studied the idea of gamifying quizzes in the classroom and compared the results to both pen and paper quizzes, and a Kahoot (2020) based quiz of the same nature. The results showed that the act of scoring and making the quiz into a game did improve the learning outcome of the students, although not by a significant margin. It was however shown to improve the engagement and enjoyment of the students taking part, and the improvement was statistically significant in this area. The study by Fotaris *et al.,* (2016)provides similar results showing that the engagement of the students taking part significantly improved with the addition of a gaming element. The results of these studies suggest that there is no negative impact on the learning outcome for the students. This shows that the gamification of feedback methods could be an excellent way to get students more engaged in their studies, and let more students enjoy the learning experience.

## Programming Assessment Methods

One area that is more complicated to effectively assess formatively is the assessment of programming skills. Sentence *et al.,* (2018)suggests that there are issues with the current method of just assessing the programming artefact that the students produce. They state that by simply assessing the end result of the programming task, that there is very minimal evidence of learning. If learning cannot be evidenced, it becomes difficult for the teacher to determine how to adjust their teaching to support the students. Another problem mentioned by Grover (2017) is that unless the programming task is undertaken in a controlled environment, plagiarism becomes an issue. There is no guarantee that the students have submitted work that is their own and therefore the teacher cannot get an accurate idea of the student’s level of knowledge. However, programming in a controlled environment may also affect the student’s quality of work and the depth of their knowledge may be misunderstood. As is evident the current form of assessment is less than ideal.

To counter these issues, Sentence (2018) suggests supplementing the usual artefact assessment method with another method of assessing the student’s abilities. They suggest three methods: assessing the process, assessment by interview and assessing the design. Assessing the process and the design of the programming artefact allows the teacher to see the thought process that has guided the student. This is where the teacher can gather meaningful information about how to adjust their teaching methods in the classroom. Alongside the assessment of the finished artefact, feedback can be distributed that will be personalised to each student to assist them in their learning of the subject.

The other method of accompanying the assessment of the artefact with an interview with the student allows for this process to become much more detailed. Having one to one feedback between student and teacher will allow for very personalised response and much more guided learning than the other methods. The issue with this approach is that too much time is required to have an individual interview with every student. One solution to save time may be the use of assessment tools like those studied by Shute & Rahimi (2016). By expediting the artefact assessment process there may be more time to spend assessing tasks using the other methods mentioned and provide more meaningful feedback to the students.

# Conclusion

Overall, formative assessment has developed substantially with the introduction of technology to the classroom, and this is especially evident in the computing environment. The introduction of automated assessment tools for things like programming exercises can be used effectively in conjunction with other forms of assessment (Sentance, et al., 2018). This collaborative approach of using modern and traditional methods of formative assessment is something that could use more research. The studies analysed in this paper tend to focus on one or the other, where perhaps a combined assessment method would yield interesting results.

Although the research studied mainly focuses on the modern methods of assessment, the traditional methods are still highly effective (Babincakova , et al., 2020). The use of self and peer assessment could be a very valuable tool with regards to assessing programming techniques and artefacts.

What this review has shown is that the addition of technology and modern assessment methods to the classroom can be effective if used correctly. There is no issue with continuing to use the traditional methods that are shown to perform admirably. The modern methods should be seen as additional tools in the teacher tool kit that are just as useful as traditional methods in the correct circumstances.

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