ICT-Integrated Formative Assessments: A Literature Review for K-12

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Abstract
Assessment is an important part of teaching and learning as it informs about teachers and learners about the progress of learning. Summative assessments have been dominant for many years and have been used mainly for categorizing or certification. Using assessments to inform teachers about their teaching and learners about their learning have gained much attention in recent years as more focus has been placed on student-centric classrooms. Black and William (2009) proposed 5 key aspects of formative assessment (FA) to guide classroom teachers in their practice of making utilizing assessments. This paper aims to review studies done with respect to technology-integrated FA in the K-12 classrooms based on the 5 key aspects. It is found that most K-12 studies lacked the consideration of clarifying and sharing learning intentions and criteria for success (aspect 1); and activating students as instructional resources for one another (aspect 4), which are important enablers for technology-based formative assessments. Areas of related topics or studies that could be explored will be discussed as well.

Keywords: Formative assessment, technology integration, ICT-integration, assessment for learning, computer-based learning

Introduction

Assessments have been an integral component of teaching and learning for decades. But for most part of time, assessments are mainly carried out to judge whether a learner has learnt the intended content knowledge and/ or able to apply the skills acquired, at the end of learning. These are summative in nature and the results are usually meant for ranking, streaming, certifying. Not much attention has been paid to the formative nature of assessments till late 20th century, whereby Black and William (1998) discussed the importance of *formative assessments* in the classroom as opposed to *summative assessments*. Formative assessments are meant to be implemented in the classroom by teachers to gather students' learning process, progress and outcomes. These in turn inform the teachers about the gaps that need to be filled before learners reach the final learning objectives. Wise teachers would pick these up and design lessons to close these gaps. Students could use feedback from the formative assessments to know which point of the learning they are at and in turn, plan their learning to achieve the learning goals.

The implementation and impact of formative assessments have been of great interests to policy-makers and academics. Much discussion has been carried out to emphasize how formative assessments are an essential feature of the 21st century learning environment (Redecker & Johannessen, 2013). Feedback from formative assessments, either from teachers, peers or self are known to help learners progress in their learning (Landauer, Lochbaum & Dooley, 2009; Espasa & Meneses, 2010).

In 2009, Black and William re-stated their definition of formative assessment and developed the theory of formative assessment, based on their earlier works which were more practice-based than theoretical-based, so as to provide a common basis for the already diversified formative assessment practices (p. 7). Their latest definition is: "Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited" (p. 9). They had also proposed the five key aspects of formative assessment to guide teachers in their practice (please refer to Table 1).

Five Key Aspects of Formative Assessment (Black & William, 2009)

	Where the learner is going	Where the learner is right now	How to get there
Teacher	1) Clarifying and sharing learning intentions and criteria for success	2) Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding	3) Providing feedback that moves learners forward
Peer	Understanding and sharing learning intentions and criteria for success	4) Activating students as instructional resources for one another	
Learner	Understanding learning intentions and criteria for success	5) Activating students as the owners of their own learning	

Table 1

With a clearer definition, vivid aspects and strategies as guidelines, it is easier to understand the fine-grained aspects of formative assessment and ponder further on how to actualise it in classroom practice, so as to help teachers gather information about where their learners are right now and how to make use of rubric, feedback, peers and self as resources to move closer to the learning objectives.

Another feature of the current and future learning environment, not be ignored, is the incorporation of information and communication technologies (ICT) in teaching, learning and assessing activities. ICT has become indispensable in modern life, both for learning and for work. Students and working adults alike are closely inter-connected via the internet, mobile smartphones, tablets etc. In a comparative analysis of international frameworks for 21st century competences, Voogt and Roblin (2012) found that the common needed skills stated across various frameworks, like *Partnership for 21st century skills (P21), EnGauge, Assessment and Teaching of 21st Century Skills (ATCS)* etc., are communication, collaboration, ICT-related competences and social and/ or cultural awareness, and "ICT is at the core of each of the frameworks" (p. 308). Regardless of teachers' attitudes on ICT in teaching, learning and/or assessing, the development and influence of ICT cannot be ignored.

Besides the need to integrate ICT into teaching and learning, how ICT can be exploited to carry out formative assessments, which are essential to help in gathering evidences about students' learning progress and outcomes, should be explored. Advancements in ICT have been more than fast enough to support formative assessments in the classrooms. Looking at the developments of future technologies, Redecker and Johannessen (2013) highlighted the possibilities of "embedded assessment", whereby Learning Analytics (a data mining capability) will be employed to collect data on students' online learning process and in turn provide information to teachers on the feedback and instructions that can be given to the students on how they can close learning gaps (p. 85). Such assessments are formative in nature and if used strategically by teachers based on sound pedagogies, it would be beneficial to educators, students and stakeholders alike. However, learning analytics is still in its infancy and had hardly been utilised in practical settings yet.

Though research on learning analytics is still limited, there are many previous and current researches that looked into how ICT could be used to support formative assessment. Espasa and Meneses (2009) concluded that the presence of feedback in online distance education is related with improved levels of performance and higher levels of student satisfaction. Welsh (2012) in her study found that self- and peer-based formative assessment was effective in developing students' self-regulation and the use of an e-portfolio system aided in the process. Timmers, Van der Broek and Van der Berg (2013) looked into the student feedback behaviour. This was an interesting aspect worth exploring as most would likely to focus on teachers giving feedback instead of the recipients of feedback. The team had defined success expectancy and task-value beliefs as the motivation behind seeking feedback.

But current literature mainly focuses on higher education and rarely on K-12 education and a review of the literature reveals that current available research does not reveal much about how K-12 teachers may organize formative technology-enabled activities in a social network setting such that they can utilize the affordances of ICT to gather evidences of learning; and provide and/or elicit feedback (from students themselves or their peers), and how they use these information to further students' learning or close learning gaps. As such, the level of assessment literacy amongst K-12 teachers is also an issue which is of interest. This paper aims to review the literature on K-12 technology-enabled formative assessment and secondary related resources, so as to explore further issues that would matter for ICT-integrated formative assessments to be carried out successfully for teaching and learning, such as the assessment literacy and social network awareness of teachers.

Methodology

Searching the literature

The search of literature was done using an authoritative electronic database, *Web of Science.* The key terms and phrases used for the search were “ICT” AND “formative assessment”; “technology” AND “formative assessment”; and “computer” AND “formative assessment”; “ICT” AND “assessment for learning”; “technology” AND “assessment for learning”; “computer” AND “assessment for learning”. The search criteria were further narrowed to peer-reviewed journal articles on educational research only. Papers from conference proceedings were not considered. The search yielded 76 articles.

Reviewing the literature

The articles were scanned and organised according to the year of publication (2015 - backwards) and how much they were relevant to the interest of study. All abstracts of the 76 articles were perused and the selection process was first based on whether the articles were written based on empirical studies. Then the studies based on K-12 were picked and the rest on higher education, literature review position papers and development of tools were classified as secondary sources. Subsequently, only empirical studies on K-12 which had themes that coincided with one or more of the five key aspects (as mentioned in Table 1) that are core to formative assessment and had it applied in an ICT-integrated teaching and learning environments were chosen. A total of 21 studies suited the selection criteria (please refer to Table 2).

Table 2 listed the studies based on chronological order. As can be seen from Table 1, there were only 21 empirical studies done on K-12 ICT-integrated formative assessment for the past 11 years. Despite the recognition that formative assessment is an important part of teaching and learning, and that ICT can provide potential affordances in actualising the 5 key aspects of formative assessment, there were not as many studies done in the levels from K-12 as desired. It could be that K-12 teachers are not in the capacity to design and create tools or systems that would be

able to carry out formative assessments effectively. What are easily accessible to them and researchers are video recordings and classroom response systems (CRS, or "clickers").

Tan and Towndrow (2008), Weir and Conner (2009), and O'Loughlin, Chroinin and O'Grady (2013) had utilized video recordings to achieve formative assessment in the areas of improving science practical sessions and physical education for the latter two and found that students' skills in these areas had improved after they were shown the videos recorded on their performance comparing with the rubric as set by their teachers.

The use of clickers was also more readily available to the teachers. There are 2 articles on classroom response systems for K-12. One is by Lee, Feldman and Beatty (2011) which focused on studying how secondary level teachers perceive the use of clickers after going through training based on CRS. The other article by Beatty and Gerace (2009) is on the use of clickers is not included in Table 2 as it described strategies on how teachers used clickers in the classroom, and is not an empirical study. They wrote on how they assist high school teachers in mastering the CRS-based pedagogical approach with 4 theoretically-based principles, of which one is formative assessment. Though the use of clickers is a quick way to gather students' understanding and learning, however its use is limited to multiple choice (MCQ) and true/false questions, which are not open-ended enough to elicit students' deeper understanding and/ or application of concepts and skills learnt. Moreover, it is probable that some students may get the answers right by chance or guessing. It is more like a paper and pen MCQ done with technology without much authenticity and opportunities for students' collaboration considered in the design of the assessment. It can be said that the CRS is not an ideal tool that can support the 5 key aspects of formative assessment, especially in the area of "activating students as instructional resources for one another", as clickers do not provide the affordance of in-depth user interaction.

Other related empirical studies done for K-12 were mainly focused on the learning systems and their formative assessment features which aided in improving students' learning outcomes in a certain subject (usually Math). To incorporate the key aspects of formative assessment into learning systems that are designed for K-12 students can be complex and time-consuming. Besides the creation of the systems, research teams (usually researchers in tertiary institutions) must ensure tests on the system are conducted; teachers need to go through professional development on formative assessment and to be trained on the systems etc. before empirical studies can be conducted. The CRS project done by Lee, Feldman and Beatty (2011) took 6 years, and Palmer and Devitt (2014) also mentioned in the conclusion of their study of an online formative assessment programme for medical students that "online medium is a valuable and appreciated resource, capable of providing timely formative feedback and stimulating student-centred learning. However, the production of quality content is a time-consuming exercise..." (p. 9). It is no wonder empirical studies on ICT-integrated formative assessment for K-12 is few and rare for the past 10 years.

Focusing on the studies in Table 2 and how far they had incorporated the 5 key aspects of formative assessment, we can see that all studies would have integrated aspects 2 and 5 ("*engineering discussions and tasks that elicit evidence of student learning*" and "*activating students as the owners of own learning" respectively*).

Aspect 2 is apparent in all studies as the online and/ or ICT-integrated assessment activities were designed to assess and gather information about students' learning and thus providing teachers with the data needed on where their learners are at on the learning trajectory. If such data is used and analysed correctly, it should facilitate teachers' future planning and design of subsequent lessons and activities to close learning gaps. To illustrate with examples, Nedungadi and Raman (2012) had developed a cloud-based adaptive learning system for Math learning. The assessment activities designed were meant to ascertain skills that individual students had mastered. The system would then diagnose students' instructional needs, monitor improvements and produce reports for teachers' perusal and further actions (p. 662). Another example, Koedinger and McLaughlin (2010) also did their study based on a Math tutoring system which assess and tutor learners concurrently. While learners were completing the online Math assessment, the system would gather and record the difficulties they face and provide feedback to teachers. In both cases, evidence on student learning had been elicited via the systems.

The online ICT learning activities of the all studies listed in Table 2 provided feedback to students. The intention is to "*activate students as owners of their own learning*" (aspect 5). Upon receiving feedback on the completed tasks, students would know where their learning position is and subsequently plan their next steps for moving towards learning success. However, not all feedback will have such effect on learners (aspect 3).

The quality of feedback given is of concern here. A score given at the end of an online task is not as helpful as a detailed comment on how to improve writing or solve a Math problem. Butler (1988) conducted a study on the impact on student achievement and attitude due to the effects of different feedback received by low and high ability students. An analysis of 132 students at the top and bottom of each class showed that those who received only scores as feedback made no improvement in their achievement. High ability (HA) students' attitude was positive, while the attitude of low ability (LA) students was negative. As for those who received only comments as feedback had a 30% gain in achievement. The attitude of both HA and LA students was positive. Such a comparison shows that giving comments as feedback helps learners more than giving scores. There were other groups in this study which received both scores and comments as feedback. Students in these groups had the same results as those who received scores only, i.e. they had 0% gain and HA students possessed positive attitude while LA students' attitude was negative. Providing both scores and comments together is as bad as giving only scores as feedback to students. It could be that when students receive both scores and comments together, they would focus on the scores instead of perusing the formative comments written by their teachers. The implication here is teachers could help LA students level up by providing them with comments instead of scores.

If scores is to be given, then the effort on writing the comments can be saved as it does not have much impact on students' gains and LA students' attitudes would remain negative.

Back to Table 2, most of the studies did incorporate the provision of feedback to learners, but it is doubtful whether the feedback provided did "move learners forward*".* Besides the quality of feedback, how learners accept and respond to feedback are key considerations which have not been investigated in K-12 yet.

Two other aspects of formative assessment which should be looked into by K-12 teachers, researchers and system engineers, are aspects 1 and 4. Aspect 1 is to "*clarify learning intentions and criteria for success*" and aspect 4 is to "*activate students as instructional resources for one another*". Of the 21 studies, only 3 explicitly mentioned the learning objectives and criteria for success to its learners by the usage of rubrics (on paper). What could be done here is to include this information into the ICT-integrated learning systems whereby teachers and all learners are clear about what it takes to attain the best performance. These can be presented in the form of rubrics (must be aligned to the learning goals), which is easier for K-12 learners to understand and operate. And rubrics serve as a common basis for everyone to provide feedback, comments and suggestions for one another (aspect 4). The lack of aspect 4 amongst the 21 studies could be due to this as well. A few studies indicated that it was part of the formative assessment process for students to discuss, comment on one another's work. Most other studies would just provide feedback to the individual student and send a report to his/ her teacher and it ends there. It would be most beneficial if the technology designed for formative assessments could tap on the ideas of social interaction to afford students to question, comment and provide feedback to their peers so as to "*activate them to be instructional resources for one another".*

Overview of the studies

Authors	Study Design	5 Key Aspects of Formative Assessment					Purpose/ Central Focus
		1	2	3	4	5	
Topping and Fisher (2003)	Experimental		X	X		X	To explore the impact of an individualised computerised assessment of student reading comprehension with feedback given to both teacher and student.
McGuire (2006)	Action research	X	X	X	X	X	To discuss how mobile phones and internet can be used to support formative assessment.
Chen and Chen (2008)	Experimental		X			X	To examine how a mobile formative assessment tool can collect and measure online learning behaviour and learning performance of Maths.
Tan and Towndrow (2008)	Case Study	X	X	X		X	To examine how the use of digital video technology can enhance student-teacher interactions in science practical formative assessment.
Weir and Connor (2009)	Qualitative		X	X		X	To investigate the use of digital video in the teaching, learning and assessment of physical education.
Koedinger and McLaughlin (2010)	Quasi-experimental		X	X		X	To examine whether a tutoring system can improve students' Maths summative scores.
Roschelle, Rafanan, Estrella, Nussbaum and Claro (2010)	Designed-based research		X	X	X	X	To examine how a software support both collaborative learning and formative assessment by providing rapid feedback at group level.
Trumpower and Sarwar (2010)	Quasi-Experimental		X	X		X	To examine the effectiveness of structural feedback provided by Pathfinder networks to improve students' structural knowledge in Physics.
Lee, Feldman and Beatty (2011)	Evaluation		X	X		X	To find out the factors that influence secondary science and math teachers' initial implementation of a pedagogy developed for teaching with CRS (clickers).
Sainsbury and Benton (2011)	Experimental		X	X			To examine the potential of the immediacy of feedback from e-assessment in helping teachers plan the next steps in teaching and learning.
Hickey, Taasoob-shirazi and Cross (2012)	Designed-based research		X	X	X	X	To explore embedding of formative assessment more directly into the curriculum.
Hickey and Zuiker (2012)	Designed-based research		X	X	X	X	To align learning across inquiry-oriented activities, feedback on formative embedded assessment and summative assessment.
McLaren (2012)	Action Research		X	X	X	X	To explore the integration of innovative methods of capturing evidence of creative performance with providing formative feedback to learners.
Nedungadi and Raman (2012)	Quasi-Experimental		X	X		X	To examine the performance, scores and perceptions of students who used a cloud-based adaptive learning system that runs on mobile devices - PDA
Bokhove and Drijvers (2012)	Design-based research		X	X		X	To investigate the effects of a digital intervention in the learning of algebraic expertise.
Crossouard (2012)	Case study		X	X		X	To explore a teacher's use of digital photography to provide 'feedback' to pupils.
O'Loughlin,	Orientational	X	X	X		X	To examine how the use of digital videos in

Chroinin and O'Grady (2013)	qualitative inquiry				primary physical education lessons impact students' motivation, feedback, self-assessment and learning.
Okita (2013)	Experimental	X		X	To examine how the application of computer tools can help students assess and self-correct their learning
Shieh and Chang (2013)	Quasi-Experimental	X	X	X	To examine the challenges teachers face when developing interactive response system (IRS) questions. And how a PD intervention helps a teacher design better IRS questions.
Chu (2014)	Quasi-Experimental	X	X	X	To investigate the possible negative effects of mobile learning by analysing the students' cognitive load and learning achievement based on a formative assessment learning strategy.
Rodrigues and Oliveira (2014)	Quasi-Experimental	X	X	X	To describe a system composed by several modules whose main goal is to work as a formative assessment tool for students and to help teachers creating and assessing exams as well monitoring students' progress.

5 Key Aspects of Formative Assessment (Black and William, 2009)
1) Clarifies and shares learning intentions and criteria for success
2) Engineers effective classroom discussions and other learning tasks that elicit evidence of student learning
3) Provides feedback that moves learners forward
4) Activates students as instructional resources for one another
5) Activates students as the owners of their own learning

Table 2

Secondary Sources of Literature

There are another 55 articles which do not belong to the K-12 empirical studies of ICT-integrated formative assessment. Some of them are position papers, some of them are literature reviews or descriptions on development of systems and tools (non-empirical), and majority of them are studies done for higher education (HE). A breakdown is listed in Table 3.

Number of articles on ICT-integrated formative assessment from 2015 and backwards

Papers on ICT-integrated formative assessment from 2015 and back	Number
Position Papers	7
Literature Review (Higher Education)	2
Development of systems/ tools (non-empirical)	3
Focus of the empirical studies in Higher Education	
• **Clickers**	7
• **Videos**	3
• **Development of systems/ tools**	9
• **Provision of Feedback**	
○ **In general**	4
○ **Scores and grades**	8
○ **Elaborated feedback**	5
○ **Peer feedback/ assessment**	7
○ **Students' motivation on feedback**	3
Pedagogy	2
Total	55

Table 3

Amongst the seven position papers, one was published more than 8 years ago, and it was authored by Gipps in year 2005 to review the role of ICT-based assessment in HE. The other four are more recent, published in year 2013. Webb (2013) proposed a framework to understand online learning, how to incorporate elements of formative assessment and build a culture that supports interaction (p. 1). The authors of the other three position papers (Spector, 2013; Redecker & Johannessen, 2013; Webb, Gibson & Forksoh-Baruch, 2013) examined current emerging technologies and

proposed future directions on what could be done in terms of technology-enabled teaching and learning. The common proposals included embedded assessment or stealth assessment; and learning analytics. Embedding assessment would mean to weave assessments for learning purposes into activities or tasks seamlessly or ubiquitously (Spector, 2013, p. 24). Making such assessments "quiet" is helpful as it takes away the emotional stress of taking tests from students. With learning analytics to collect data and information on students' online interactions and performance, teachers who can analyse and interpret the data would truly know how their students have learnt, grasped and able to apply knowledge and skills. With the fast advancement of technology, learning analytics should be ready in two to three years' time. However, it is the non-readiness of our teachers which would be the barrier to this actualisation. The need for teachers to build capacity on assessment literacy has been brought up by various authors.

Referring back to table 2, it is apparent that there are more studies done and articles written on formative assessment for higher education (55 as compared to 21 for K-12). There are also studies on the use of clickers, video technology and to carry out formative assessment but the majority of studies revolved round online "feedback" (29 out of 55).

Feedback

There are a few areas of concern which have been investigated in HE that had been lacking in K-12. Firstly, the types of automated feedback provided by ICT systems, which students tap on to "move forward" towards learning goals, were examined. Whether the feedback provided by the learning system is only a score, right or wrong, immediate or delayed, written and elaborated, does have implications on what learners can use and how they can further their learning. Lipnevich and Smith (2009) had conducted a study on HE students' response and perceptions on the various methods and quality of feedback they received. They also collected students' views of the "ideal" feedback. They found that all students in the study agreed that the most useful type of feedback that helped them propel forward was detailed comments. Grades were deemed as undesirable and impeded improvement. Laudatory comments or praise had the least impact (p. 364).

Van der Kleij, Eggen, Timmers and Veldkamp (2011) did a study on the impact of different types of feedback provided to students of a Commercial Economics course. Students in the sample were divided into 3 groups. The first group received immediate knowledge of correct response (KCR) and elaborated feedback (EF) after completing each question. The second group received the same EF but would only know the correct response after they had completed the all the questions in the assessment. The third group only received feedback on whether they had answered correctly after answering the whole set of test. With such a set up, it was hypothesized that students in group 1 would have performed much better than the other 2 groups. On the contrary, there were no effects of feedback found on learning (p. 269). It could be due to the fact the formative assessment was done just before a summative assessment was conducted, whereby all students would have prepared

well beforehand. Students' perception survey reflected that students prefer immediate feedback than delayed feedback. The time log of how long a feedback screen was kept opened indicated that students were more likely to pay attention to immediate feedback. The implication of this study is the timing of providing feedback and help is an important consideration for ICT-integrated formative assessments.

Next, the acceptance of different types of feedback by the learners and how willing they are in responding to it are brought to attention by Timmers, Van den Broek and Van den Berg (2012). In their study, they investigated the relationships between students' motivational beliefs, effort and feedback behaviour. Feedback can only be impactful when students seek it and process it (p. 25). There is no point in teachers providing detailed and lengthy feedback when students are reluctant and not motivated to spend time on it to improve their performance. The factors affecting students' motivation in seeking feedback include task-value beliefs and success expectancy. The higher the task-value beliefs and success expectancy, the more likely would a student seek feedback. Teachers and designers of learning systems should keep motivational factors in mind (p. 30).

Detailed studies on feedback have been more prevalent in higher education whereas it is apparently lacking in K-12. The empirical results from the studies can be tested and applied in K-12 context eventually.

Rubrics and Teachers' Assessment Literacy

Besides automated feedback, it is worth while looking at how teachers, peers and self can assess and provide feedback to one another in an ICT system, thus actualising the aspects on "activating students as instructional resources for one another" and "activating students as the owners of their own learning" (aspects 4 and 5 of formative assessment). However to actualise this, teachers and learners require a common basis of measurement that can be utilised to assess completed tasks or work-in-progress assignments. A rubric that matches the learning objectives would be necessary to aid in the process. And such a rubric should be incorporated into the ICT-integrated formative assessment system to convenience the feedback process. A well-developed rubric that facilitates peer assessment and feedback is essential but whether teachers have the capacity to come up with good rubrics is questionable. Zhu (2012) studied a sample of 41 scoring rubrics designed by Chinese language teachers from Singapore and found them unsatisfactory and problematic. The identified problems included mismatches of criteria and descriptors; and negative and obscure descriptors. Zhu suggested professional development (PD) in the area of teachers' assessment literacy, so as to maximise the benefits of using formative assessment to bring about improved teaching and learning.

Besides the design of good rubrics, teachers must train students to have the ability to assess their own work and peers' work so as to provide quality and meaningful feedback that moves one another forward. The seven principles of good feedback practice (Nicol & MacFarlane-Dick, 2006) must be considered and conveyed to the students. Though peer interaction, for example seeking peers' feedback (much

afforded by the use of technology), is beneficial, it is important for players, especially teachers, to be aware of the workings of social network and how it could be made use of to carry out dialogue that revolves learning, that benefits all in the class. What could be of help here would be the knowledge and application of social interactions in formative assessment.

Social Interactions in Formative Assessment

Interactions amongst learners are deemed as an important and are a natural way of learning (Hiltz, 1994, p. 22). Black and William (2009) also proposed "activating learners to become instructional resources for one another". One of the seven good feedback practices as presented by Nicol and MacFarlane-Dick (2006) also "encourages teacher and peer dialogue around learning" (p. 205). Social interactions amongst peers are strongly encouraged.

With technology providing such ease and convenience for communication, opportunities for online interactions amongst peers for the purpose of learning should be created and enabled. Krejins, Kirschner and Vermeulen (2013) had identified two problems of social interactions not happening even after computer-supported collaborative learning (CSCL) environments had been developed for students to interact with one another. One of the problems is the lack of social interactions within the environments. With so few posts, it is indeed hard to attract more students to get interested to leave messages for others to read. The second problem is that the socio-emotional aspect of social interaction has been neglected or overlooked (p. 230). Authors proposed increasing the sociability, forming a safe social space and emphasizing social presence for CSCL environments. Actually, besides all these, we could incorporate the "peer interaction/ feedback" component of formative assessment into CSCL environments.

To further illustrate, upon understanding the requirements and criteria for success of an online formative assessment task, a student completes his work, checks his performance against the requirements, reviews and/or amends, and then submits his work online. Subsequently, he can invite his teacher and peers to provide feedback and comments based on a teacher-designed rubric (or the criteria for success) that serves as a common basis for discussion for performance. He can also review his peers' submission and give comments that aid in closing the gap to learning success. Clarifications and words of encouragement can be made in the online environment and further comments can be sought if necessary. The dialogue and interactions will be focused and hopefully dynamic and fluid. By analysing the submissions and interactions (with the help of learning analytics), the teacher can also gather evidence on learners' learning outcome and plan for future interventions.

Conclusion

Based on the review above, we can see that there are more research and studies conducted in the HE sector. These studies had been important as they shone much

light on areas and topics in ICT-integrated formative assessment which have great implications for teachers and designers of learning systems with formative components. The essential points to note are the types, timing and quality of feedback that would motivate students to sought after and work on further to improve themselves. For formative assessment to work, teachers' assessment literacy must be heightened. With the infusion of ICT, the possibility of formative assessment in CSCL environments, and implementation of learning analytics in data collection of students' online footprints, it is all the more necessary for teachers to develop awareness, knowledge and skills in these areas. Formative assessment and CSCL can be put together to bring about richer interactions amongst learners but the theories and actual applications need to be further explored and researched upon.

As mentioned earlier, studies on K-12 technology-enabled formative assessment have been lacking. Areas that should be explored include: 1) how K-12 students accept and respond to different types of online feedback; 2) would the provision of an online criteria for success or online rubric facilitate students' feedback, comments and discussions on one another's work; 3) how K-12 teachers may plan for and organize formative technology-enabled activities based on social interaction such that they can utilize the affordances of ICT to gather evidences of learning; and provide and/or elicit feedback (from students themselves or their peers); and 4) how to build K-12 teachers' capacity in assessment literacy.

To maximise the benefits of technology-based formative assessment for teaching and learning, teachers' assessment literacy must be developed. Concurrently, pedagogies for formative assessment to be incorporated into CSCL should be explored.

References

Beatty, I. D., and Gerace, W. J. (2009). Technology-enhanced formative assessment: A research-based pedagogy for teaching science with classroom response technology. *Journal of Science Education and Technology*, *18*(2), 146-162.

Black, P., and William, D. (1998). Assessment and Classroom Learning, *Assessment in Education: Principles, Policy and Practice*, 5(1), 7-74.

Black, P., and William, D. (2009). Developing the theory of formative assessment, *Educational Assessment, Evaluation and Accountability*, 21(1), 5-31.

Bokhove, C., and Drijvers, P. (2012). Effects of a digital intervention on the development of algebraic expertise. *Computers and Education*, *58*(1), 197-208.

Butler, R. (1988). Enhancing and undermining intrinsic motivation: The effects of task- involving and ego- involving evaluation on interest and performance. *British Journal of Educational Psychology*, *58*(1), 1-14.

Chen, C. M., and Chen, M. C. (2009). Mobile formative assessment tool based on data mining techniques for supporting web-based learning. *Computers and Education*, *52*(1), 256-273.

Chu, H. C. (2014). Potential Negative Effects of Mobile Learning on Students' Learning Achievement and Cognitive Load-A Format Assessment Perspective. *Educational Technology and Society*, *17*(1), 332-344.

Crossouard, B. (2012). Pupil mortification: digital photography and identity construction in classroom assessment. *British Journal of Sociology of Education*, *33*(6), 893-911.

Espasa, A., and Meneses J. (2009). Analysing feedback processes in an online teaching and learning environment: an exploratory study, *Higher Education,* 59(3), 277-292.

Gipps, C. V. (2005). What is the role for ICT- based assessment in universities? *Studies in Higher Education*, *30*(2), 171-180.

Hickey, D. T., and Zuiker, S. J. (2012). Multilevel assessment for discourse, understanding, and achievement. *Journal of the Learning Sciences*, *21*(4), 522-582.

Hickey, D. T., Taasoobshirazi, G., and Cross, D. (2012). Assessment as learning: Enhancing discourse, understanding, and achievement in innovative science curricula. *Journal of Research in Science Teaching*, *49*(10), 1240-1270.

Hiltz, S. R. (1994). The virtual classroom: Learning without limits via computer networks. Norwood, NJ: Ablex.

Koedinger, K. R., McLaughlin, E. A., and Heffernan, N. T. (2010). A quasi-experimental evaluation of an on-line formative assessment and tutoring system. *Journal of Educational Computing Research*, *43*(4), 489-510.

Kreijns, K., Kirschner, P. A., and Vermeulen, M. (2013). Social aspects of CSCL environments: A research framework. *Educational Psychologist*, *48*(4), 229-242.

Landauer, T. K., Lochbaum, K. E., and Dooley, S. (2009). A new formative assessment technology for reading and writing. *Theory into Practice*, *48*(1), 44-52.

Lee, H., Feldman, A., and Beatty, I. D. (2012). Factors that affect science and mathematics teachers' initial implementation of technology-enhanced formative assessment using a classroom response system. *Journal of Science Education and Technology*, *21*(5), 523-539.

Lin, J. W., and Lai, Y. C. (2013). Online formative assessments with social network awareness. *Computers and Education*, *66*, 40-53.

Lipnevich, A. A., and Smith, J. K. (2009). "I really need feedback to learn:" students' perspectives on the effectiveness of the differential feedback messages. *Educational Assessment, Evaluation and Accountability*, *21*(4), 347-367.

McGuire, L. (2005). Assessment using new technology. *Innovations in Education and Teaching International*, *42*(3), 265-276.

McLaren, S. V. (2012). Assessment is for learning: supporting feedback. *International Journal of Technology and Design Education*, *22*(2), 227-245.

Nedungadi, P., and Raman, R. (2012). A new approach to personalization: integrating e-learning and m-learning. *Educational Technology Research and Development*, *60*(4), 659-678.

Nicol, D. J., and Macfarlane- Dick, D. (2006). Formative assessment and self- regulated learning: a model and seven principles of good feedback practice. *Studies in higher education*, *31*(2), 199-218.

O'Loughlin, J., Chróinín, D. N., and O'Grady, D. (2013). Digital video: The impact on children's learning experiences in primary physical education. *European Physical Education Review*, *19*(2), 165-182.

Okita, S. Y. (2014). Learning from the folly of others: Learning to self-correct by monitoring the reasoning of virtual characters in a computer-supported mathematics learning environment. *Computers and Education*, 71, 257-278.

Palmer, E., and Devitt, P. (2014). The assessment of a structured online formative assessment program: a randomised controlled trial. *BMC medical education*, *14*(1), 8.

Redecker, C., and Johannessen, Ø. (2013). Changing Assessment—Towards a New Assessment Paradigm Using ICT. *European Journal of Education*, *48*(1), 79-96.

Rodrigues, F., & Oliveira, P. (2014). A system for formative assessment and monitoring of students' progress. *Computers & Education*, *76*, 30-41.

Roschelle, J., Rafanan, K., Estrella, G., Nussbaum, M., and Claro, S. (2010). From handheld collaborative tool to effective classroom module: Embedding CSCL in a broader design framework. *Computers and Education*, *55*(3), 1018-1026.

Sainsbury, M., and Benton, T. (2011). Designing a formative e- assessment: Latent class analysis of early reading skills. *British Journal of Educational Technology*, *42*(3), 500-514.mc

Shieh, R. S., and Chang, W. (2013). Implementing the interactive response system in a high school physics context: Intervention and reflections. *Australasian Journal of Educational Technology*, *29*(5).

Shih, R. C. (2011). Can Web 2.0 technology assist college students in learning English writing? Integrating Facebook and peer assessment with blended learning. *Australasian Journal of Educational Technology*, *27*(5), 829-845.

Spector, J. M. (2013). Emerging Educational Technologies and Research Directions. *Educational Technology and Society*, *16*(2), 21-30.

Tan, A. L., and Towndrow, P. A. (2009). Catalyzing student–teacher interactions and teacher learning in science practical formative assessment with digital video technology. *Teaching and Teacher Education*, *25*(1), 61-67.

Timmers, C., Van den Broek, J.B., and Van den Berg, S. M. (2013). Motivational beliefs, student effort, and feedback behaviour in computer-based formative assessment, *Computers and Education,* 60(1), 25-31.

Topping, K. J., and Fisher, A. M. (2003). Computerised formative assessment of reading comprehension: field trials in the UK. *Journal of research in reading*, *26*(3), 267-279.

Trumpower, D. L., and Sarwar, G. S. (2010). Effectiveness of structural feedback provided by Pathfinder networks. *Journal of Educational Computing Research*, *43*(1), 7-24.

Van der Kleij, F.M., Eggen, T.J.H.M., Timmers, C.F., and Veldkamp B.P. (2012). Effects of feedback in a computer-based assessment for learning, *Computers and Education, 58*(1), 263-272.

Voogt, J., and Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299-321.

Webb, M. (2013). Changing models for researching pedagogy with information and communications technologies. *Journal of Computer Assisted Learning*, *29*(1), 53-67.
Webb, M., Gibson, D., and Forkosh- Baruch, A. (2013). Challenges for information technology supporting educational assessment. *Journal of Computer Assisted Learning*, *29*(5), 451-462.

Weir, T., and Connor, S. (2009). The use of digital video in physical education. *Technology, Pedagogy and Education*, *18*(2), 155-171.

Welsh, M. (2012). Student perceptions of using the PebblePad e-portfolio system to support self- and peer-based formative assessment, *Technology, Pedagogy and Education,* 21(1), 57-83.

William, D., and Thompson, M. (2007). Integrating assessment with instruction: What will it take to make it work? In C. A. Dwyer (Ed.), *The future of assessment: Shaping teaching and learning*, 53-82. Mahwah, NJ: Erlbaum.

Zhu, X. H. (2012). Advocating assessment for learning: Problems of Teachers' Scoring Rubrics in the early stage of development and possible solutions, *Journal of Chinese Language Education, (10)*2, 1-20.

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