# Technology-enabled feedback: It's time for a critical review of research and practice

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Globally, there are significant policy initiatives and commitment of resources towards technology-enabled feedback (TEF) adoption across the k-16 spectrum. TEF suffers from chronic problems, however. Sustained integration of TEF into curricula is infrequent; technology abandonment remains common. This paper explores the gap between TEF aspiration and adoption through a review of relevant literature. The literature review is treated as act of research; a sequential method of identifying, evaluating, and critically analysing sources was applied and is thoroughly explained. Findings are presented and discussed. These include a fundamental quality concern within the field of TEF research that may impact legitimacy of research to inform both further research and sustained adoption. Recommendations are made for addressing concerns and achieving progress.

Keywords: technology-enabled feedback, feedback, assessment, review

## Introduction

For over half a century, technology has been promoted as enhancing feedback in formal testing. Increasing hardware and software sophistication have encouraged attempts to expand technology's role in enabling formal and informal processes of feedback and more generally, assessment. This in turn has led to policy initiatives and significant commitment of resources towards Technology-enabled feedback (TEF) adoption across the k-16 spectrum.

The potential of TEF is tempered by problems. Sustained integration of TEF into curricula is infrequent; technology abandonment remains common (Deneen, Brown, & Carless, 2017). What accounts for persistent gaps between aspiration and actuation? Some relevant answers lie within existing literature in terms of findings and characteristics of the literature on TEF, itself. This paper aims to address the gap between TEF aspiration and adoption through reporting findings from a systematic and critical review of relevant literature.

The objectives of the review were to:

1. Determine findings relevant to issues of TEF adoption
2. Evaluate relevant quality characteristics of literature on TEF, and
3. Present ways forward that may inform further research and approaches to TEF adoption.

## Background and Perspectives

Technology-Enabled Assessment (TEA) may be understood as assessment of, for and as learning where technology is leveraged to benefit assessment experience or outcomes (Jordan, 2013). TEF then may be understood within that context, where leveraged benefit focuses on the experience or impact of feedback (Gomez et al, 2013). We draw on Hattie and Timperley's seminal work to define feedback as "information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding (2007; p. 81).

As early as the 1960s, automated marking systems were promoted as saving time and resources in generating performance indicators, while reducing the drudgery associated with staff marking (Dikli, 2006; Warschauer & Ware, 2006). Developments in computer hardware and software led to the allowance of more varied inputs and the affordance of more than numerical scores, shifting TEF from a largely summative orientation toward provision of feedback for formative purposes (Warschauer & Ware, 2006).

The pervasiveness of the Internet during the early 2000s gave birth to a plethora of TEF applications such as web-portals, online discussion forums and learning management systems giving teachers the opportunity to

directly interface with TEF, evaluating and delivering feedback more quickly to students (Warschauer & Ware, 2006). By the late 2000s, audio and video feedback, as well as screencasts of instructional feedback could be utilized through computers and the Internet. Through these developments, TEF evolved away from automated efficiency towards harnessing technology for providing richer, multimodal provision.

Recently, TEF has included development of computers as intelligent agents of feedback. Intelligent tutoring systems and adaptive testing engines are increasingly able to provide specific and directed feedback in response to learners' on-going interactions with computers. These systems are even capable of making data-informed recommendations on follow-up tasks intending to consolidate learning efforts.

Meta-analyses investigating the effects of computer feedback on student writing found significant positive effects on quality (Bangert-Drowns, 1993; Cochran- Smith, 1991; Goldberg, Russell, & Cook, 2003). Attali (2004) reported that through regularized TEF usage, students demonstrated enhanced capabilities in correcting errors and effectively improving their work in subsequent submissions.

There are significant causes for concern, however. Studies on TEF over the past few decades have been directed towards demonstrating high levels of agreement and correlations between computer-generated and human scores and feedback without evaluation of merits of the actual feedback message (Burstein et.al., 1998; Attali & Burstein, 2006; Warschauer & Ware, 2006). Warschauer and Ware (2006) expressed concern that much of TEF research is funded and even carried out by companies that produce commercial TEF products. They noted we are left with doubts regarding legitimacy of results.

Thus, an examination of problems in TEF must focus both on research results, and relevant quality characteristics of the research.

## Methodology

Scoping this review requires clearly defined boundaries of what constitutes TEF. In enabling feedback, technology must be more than simply enacting feedback. As such, technology is said to enable feedback only when it presents an alternative that adds value beyond that presented by a "low-tech" solution. An extensive search involving multiple passes was then conducted. A first pass with Google Scholar revealed a vast body of TEF publications, which were diverse in quality. Many of these, despite being labelled as scholarship, were found to be lacking in methodological soundness and rigor.

The search was then enhanced with hand searches on a core group of relevant high-impact journals. The reference lists of identified high-impact publications were examined and compared to identify high-impact articles that appeared frequently. Further, consultation on sources was sought from two experts in educational technology and assessment. This led to an initial list of 35 articles that met the basic criteria of inclusion. The authors split the list of articles and engaged in a two-pass system for determining quality, relevance, and methodological soundness. As this is a critical review, several articles were intentionally included to demonstrate the wide range of methodological soundness.

A reliability exercise was then conducted between the two authors (Fink, 2005). Results were compared, discussed and adjusted. Once sufficient inter-reader reliability had been established, the articles were divided between the two authors and full systematic abstracting commenced. This involved identifying a priori categories pertaining to typology, context, methodology and findings (see Table 1). Such an approach falls within the realm of meta-synthesis. Emergent categories and codes were derived from within a priori categories established separately by each author. This process was accomplished in a multi-sage progress involving both authors and an external research assistant. The authors then came together to stabilize categories, codes and axial relationships between and among them.

We adopt the perspective that reviewing literature review is an act of research (Fink, 2005). Concomitant with this is the requirement that reporting review results must include a clear account of a defensible methodology (Smagorinsky, 2008). We use the term "critical review" as our intention is to go beyond reporting a research-derived narrative of best practices.

**Table 1: Processes of enabling feedback in several TEF systems**

| TEF System | Reported by | Technology enables feedback by | | |
|---|---|---|---|---|
| | | Acquiring | Transforming | Conveying |
| Websites that Host Feedback | Harrison et.al.(2013) | | | ✔ |
| Audio Feedback | Cann (2014); Henderson & Phillips (2014); Hennessy & Forrester (2013); McCarthy (2015) | ✔ | | ✔ |
| Video & Screencast Feedback | Barry (2012); Crook et.al. (2012); Henderson & Phillips (2014); Henderson & Phillips (2015); Marriott & Teoh (2012); McCarthy (2015); West & Turner (2015); Yuan & Kim (2015); Phillips, Henderson & Ryan (2016) | ✔ | | ✔ |
| Discussion Forums | Coll et.al. (2013); Shroff & Deneen (2011); Huang & Hung (2013) | ✔ | | ✔ |
| Messaging Systems & LMS | Horvadas et.al. (2013); Lai & Hwang (2015); Burrows & Shortis (2011) | ✔ | | ✔ |
| Adaptive Grade Release | Hepplestone et.al. (2011); Irwin et.al. (2012); Parkin et.al. (2011) | ✔ | | ✔ |
| e-Learning Applications | Shute & Towle (2003); Van der Kleij et.al.(2015); Timmers et.al.(2013) | ✔ | ✔ | ✔ |
| Automated Marking Systems | Jordan (2011); Jordan (2012); Jordan (2013); Jordan & Mitchell (2009); Dikli (2006); Warschauer & Ware (2006); Chowdorow et.al. (2010); | ✔ | ✔ | ✔ |
| Intelligent Tutoring Systems | Narciss (2014) | ✔ | ✔ | ✔ |
| Computer Games | Shute (2011); Shute & Ke (2012); Nino & Evans (2015) | ✔ | ✔ | ✔ |

## Scope

Key constructs and terms were identified, with the core term setting scope, 'technology-enabled feedback.' The search also focused on assessment (inclusive of assessment of, as and for learning) and more specifically, feedback (inclusive of feed forward). Technology was intentionally setting as inclusive of key areas such as smartphones and mobile technology. We consider technology as a continuum from "high tech" to "low tech." Anything using computer devices and/or the internet or a more sophisticated engagement with technology was considered.

Not surprisingly, there was a high concentration of relevant papers within technology-oriented education journals. The scope of sources was intentionally set beyond just these journals, as failing to do so might bias results.

## Literature search & abstraction

Search strings were derived from the scope. An extensive search of the literature with multiple passes was conducted. A core group of relevant, high-impact journals were identified and hand searches were conducted within these journals. Reference lists of identified high-impact publications were examined. Finally, expert consultation on sources was sought from two scholars in educational technology and educational assessment. An initial list of 35 articles meeting the basic criteria of admission. This was reduced to 25 articles through a two-pass system for determining quality and eliminating unqualified articles (Fink, 2005). As this is a critical review, articles from high-impact journals were intentionally left in demonstrating a range of methodological soundness.

A reliability exercise was conducted between the two authors until a kappa score of .8 was achieved (Fink, 2005). Following this, article abstraction was conducted using a priori categories according to quality, typology, context, methodology and findings.

### Analysis

Within a priori categories, emergent categories and codes were derived. This was accomplished in a multi-stage progress involving both authors and an eternal research assistant. Initial emergent categories and codes were established by each author, separately. Then, the authors came together to stabilize categories, codes and axial relationships between and among both. An approach was adopted similar to the multipass approach advocated by Saldaña (2015) for analysing qualitative data.

## Results of the Review

The analysis surfaced three primary areas for exploration. These pertain to how feedback is enabled, how TEF systems are evaluated, and how they perform.

### Enabling Feedback

Feedback provision involves the acquisition of information from learners, the transformation of the acquired information into feedback, and the transmission of feedback to the learner. Technology is said to enable feedback because it can perform at least one of these in ways that humans cannot. From this review, the majority of TEF systems use technology to only acquire and transmit information. This surfaces two categories of TEF systems – those where technology transforms information, and those where technology does not.

TEF systems that do not transform information tend to focus on acquisition and presentation of information. These typically use text and audio-visual modalities to capture, distribute, and store digital information. As technology is not involved in modifying information, some human action is necessary. Feedback processes are enabled as tutors are afforded the facility to self-record any feedback on learners' work and host them on online portals (Crook et.al., 2012; Marriott & Teoh, 2012; McCarthy, 2015; Phillips, Henderson & Ryan, 2016; West & Turner, 2015). A key concern of such TEF systems is the lack of design guidelines and principles that encourage learning and engagement. Several studies have recognized this concern and developed guidelines for implementation (Hennessy & Forrester, 2013; Cann, 2014; Barry, 2012; Yuan & Kim, 2015; Henderson & Phillips, 2014). With such TEF systems however, technology's purpose is to passively convey acquired information.

TEF systems where technology's role includes transforming information tend to focus on what technology can autonomously do with acquired information. Among these are adaptive e-Learning applications and automated scoring systems. Shute and Towle (2003) discussed the use of adaptive e-Learning applications and proposed a framework to guide their design. These systems operate by administering simple tasks and collecting information from learners. Feedback is then automatically generated or selected from a statement bank. These systems are then able to recommend appropriate follow-up tasks to check if they have internalized the feedback messages. A drawback of these systems, however, is that their operation is often limited to selected-response questions and numerical answers entered into a text field (Jordan, 2013). One approach to overcome this lies in the development of computational algorithms based on natural language processing techniques that enable computers to automatically assess free-text responses from learners (Chowdorow, Gamon & Tetreault, 2010; Jordan, 2011).

These two types of TEF systems emphasise different aspects of the feedback process and are thus evaluated differently. These approaches are discussed next.

### Evaluating TEF Systems

Many of the reviewed studies assess the merits of TEF systems in consideration of their technological affordances. TEF systems where technology only acquires and transmits information are typically evaluated in terms of how conveniently these processes take place. These typically use interviews, focus group discussions, and questionnaires as their primary means of data collection.

TEF systems where technology transforms information tend to measure engagement using digitally acquired information from learner interactions, such as the amount of time spent on feedback messages (Timmers, Van

Den Broek, & Van Den Berg, 2013) and logs of activity (Chowdorow et.al., 2010; Hepplestone et.al., 2011; Parkin et.al., 2011; Irwin et.al., 2012; Narciss et.al., 2014). Some of these studies have also examined the effects of TEF systems on motivation, self-efficacy, goal-orientation, self-regulation, confidence (Harrison et.al., 2013) and achievement (Narciss et.al., 2014; Van der Kleij, Feskens & Eggen, 2015).

The various approaches discussed here reflect what these studies consider to be of merit for TEF systems. Interestingly, very few studies evaluate TEF systems based on how well they enact the principles of educational and assessment research. TEF systems are instead typically evaluated for their technological affordances and user satisfaction. Further, most of these evaluations are conducted using questionnaires and interviews conducted by researchers who are also the developers of these systems.

### TEF Performance

Four different types of TEF systems have been identified for evaluation. These include audio-visual technologies, learning management systems, e-learning applications and automated scoring systems. It may be noted that only the latter two types of TEF systems involve the autonomous use of technology to transform information into feedback.

Audio-visual feedback has been reported to be largely popular for their clarity and usefulness and personalized nature (Henderson & Phillips 2014; Crook et.al., 2012; Barry, 2012; Cann, 2014). These alternative modalities of feedback provision correlate positively with improved student experience, leading to greater engagement (Phillips et.al., 2016; Barry, 2012; Crook et.al., 2012) and have led to savings in staff time (Henderson & Phillips, 2014). These modalities, however, are not without problems. Learners can suffer an initial feeling of anxiety when receiving video feedback, and some may encounter difficulties in matching video feedback to specific sections of their assignments (Henderson & Phillips, 2014).

Learning management systems allow for the convenient uploading and access of feedback information, and allow for the tracking of access statistics. Learners were found to be appreciative of the benefits offered by such systems (Parkin et.al., 2012). Further, higher performing students were found to have been more proactive in frequently accessing online feedback (Harrison et.al., 2013).

E-Learning applications have been reported to have positive effects on learner motivation, task-value beliefs, success expectancy, and academic achievement. These positively correlate to learners' efforts in seeking feedback from such systems (Timmers et.al., 2012; Narciss et.at., 2014). Moreover, the effects of such systems on learning have also been found to be largely positive.

Automated scoring systems have been evaluated based on how well they can engage learners and improve their academic performances. Chowdorow et.al. (2010) observed that learners became more selective among the corrections suggested by one such system, whereas Jordan and Mitchell (2009) noted that students do not always read computer-generated feedback, as they remain unconvinced that the system understood their responses. Moreover, automated marking systems has been found to improve academic achievement, and that suggested corrections to learner responses led to higher quality work (Chowdorow et.al., 2010).

Interestingly, most of the findings on learning and achievement were reported for TEF systems where technology is used in the transformation of information into feedback messages. Where technology functions as the enabler of information acquisition and transmission, the focus is substantially more on achieving efficiency and less so on learning. Consequently, the design of these TEF systems tends to be influenced more significantly by these outcomes, rather than by how well they enact some of the principles in education research. In the next section, we discuss the some of the implications of these findings.

## Discussion

Despite the reported benefits of TEF systems, the lack of sustained TEF adoption raises several questions over the legitimacy of research findings that have seem remarkably positive.

First, it must be noted that TEF research is largely conducted by researchers who are themselves the innovators of TEF systems. Any lack of objectivity in research can therefore result in claims that are skewed towards the merits of the innovation. These include overly generic conclusions such as "the majority of students liked it and found it useful". Very few studies reported on rigorous follow-up procedures that could have absolved

themselves of any suspicion of bias. Consequently, the lack of rigor and soundness in TEF research procedures may have been the cause of unjustified claims that do little more than showcase potential.

Second, many of these studies were conducted by researchers whose primary focus lies in technological development, and not in education research. As the discourse in TEF development is driven and dominated by technologists, it is inevitable that there are extensive discussions on technological affordances, and not what educational institutions require. As these fundamental requirements are not met, sustained adoption is unlikely.

Third, as technologists are not responsible for theorizing the principles of assessment and feedback within the various disciplines, they may not appreciate the specific disciplinary variations when applying their innovations in different schooling contexts. It consequently becomes difficult for education researchers to critically examine and evaluate these innovations in relation to well-established feedback principles. In terms of practice, the absence of critical evaluation in specific contexts makes adoption difficult to justify. This is especially the case as very few of these TEF systems have been developed using any theoretically informed framework. The possibilities of dissemination of best practices for continued TEF development are thus limited.

## Conclusion

This review has identified possible reasons for the lack of sustained adoption of TEF systems. While substantial effort has been made to showcase the affordances of TEF systems, some of the adopted research methods appear to lack rigor and may be subject to bias. Further, a disproportionate amount of effort has gone into illustrating what actually works in TEF, as opposed to explaining why they work and who they best work for. TEF research is overly focused on technological development, with only superficial consideration for principles in feedback and assessment. It thus remains that the focus "has not been on using technologies to address fundamental educational issues" as pointed out by Nicol and Milligan (2006, p.11) more than a decade ago, despite substantial technological advancement since. Until these issues are resolved, the promise of TEF is unlikely to be fulfilled.

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