Evidence summary

Motivation, feedback and mindsets in learning with edtech

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Introduction

When developing and using educational digital environments, it is important to consider the conditions that are known to promote learning. Learning is a complex process and there are many factors and conditions that affect its quality.

This review very briefly covers the constructs of motivation, feedback and mindset in education to help us understand how edtech products and services might be enhanced. The aspiration is to help everyone to improve the efficacy and impact of edtech tools by shaping approaches to their design and development.

Defining motivation

Motivation is defined as an internal state or condition that directs human behaviour towards a goal. It is widely believed that a positive motivational state – often observed as enjoyment, affective engagement and situational interest – can have a positive effect on learning outcomes. It follows that learning can be enhanced by increasing the occurrence of these states (Lazowski and Hulleman, 2016; Yeager and Walton, 2011).

It follows that designers of new instructional interventions and innovative educational tools may consider using motivational triggers in their products. The role that motivation plays within learning becomes more important, given the move towards more open, innovative, informal and independent learning experiences both within and outside of the school, college or university environment. The possibility of learners' independent use of such tools highlights the importance of the careful design of motivational, feedback and mindset-related elements.

In 2016, Lazowski and Hulleman published an extensive summary of intervention studies in education that are grounded in motivation theory. This identified experimental studies that manipulated an independent variable related to motivation, and measured the impact on educational outcomes within educational contexts. The summary concluded: "motivation interventions have demonstrated promising results for enhancing educational outcomes" (p.624).

Pintrich (2003) attempts to answer the question: What motivates students in the classroom?. He developed a list of student motivations, accompanied by a set of design principles, that promote such motivations (see Table 1).

Most of these design principles, if not all, should be taken into account within the design of educational technologies. It is important to note that these generalisations and design principles need to be appropriated to the local contexts (such as educational environment, learner characteristics, and the subject being studied) – and that they interact with each other. Of course, this applies to any guiding design principles for educational resources.

Table 1 Motivational generalisations and design principles (from Pintrich, 2003, p.672)

Motivational generalisation	Design principle
Adaptive self-efficacy and competence beliefs motivate students.	• Provide clear and accurate feedback on competence and self-efficacy, focusing on the development of competence, expertise, and skill.

(When learners are expected to do well, they try hard, persist and perform better)	• Design tasks that offer opportunities to be successful but also challenge students.
Adaptive attributions and control motivates students.	• Provide feedback that stresses the processes involved in learning, including the importance of effort, and strategies and potential for self-control of learning. • Provide opportunities for learners to exercise choice and control. • Build supportive and caring personal relationships in the community of learners in the classroom.
Higher levels of interest and intrinsic motivation motivate students.	• Provide stimulating and interesting tasks, activities and materials, to include novelty and variety in tasks and activities. • Provide material and tasks that are meaningful and interesting to students. • Display and model interest and involvement in the content and activities.
Higher levels of value motivate students.	• Provide tasks, material and activities that are relevant and useful to students, allowing for some personal identification with school. • Classroom discourse should focus on importance and utility of content and activities.
Goals motivate and direct students.	• Use organisational and management structures that encourage personal and social responsibility and provide a safe, comfortable, and predictable environment. • Use cooperative and collaborative groups to create opportunities to attain both social and academic goals. Classroom discourse should focus on mastery, learning, and understanding course and lesson content. Use task, reward, and evaluation structures that promote mastery, learning, effort, progress, and self-improvement standards rather than social comparison or norm-referenced standards.

It is clear from this table that there is no single ‘right way’ to design edtech and their classroom implementations to foster motivation and learning. Motivating learning environments can be designed, organised and structured in a variety of different ways (Pintrich, 2003). While designing edtech, it is beneficial to take these principles into account and attempt to achieve as many of them as possible. How these principles can be achieved depends on the type and implementation of the edtech tool. For example, tools that encourage exploratory learning using simulations of specific content can lead to high levels of intrinsic motivation, whereas extrinsic motivators might be needed to promote engagement in a content that is more aligned to mandatory test regimes.

Motivation and learning have also been considered in depth alongside the construct of ‘cognitive conflict’ in learning environments and game-based learning. Cognitive conflict refers to the presentation of “anomalous data or contradictory information” (Limon, 2001, p.357) to students as a teaching strategy to support students’ conceptual development. However, such data or information needs to be close enough to students’ existing understanding for this approach to be useful and not result in ‘cognitive overload’.

Researchers (D'Mello et al., 2014) have carried out experiments to test the effect of confusion on learning, and explored if it promoted "deep inquiry and effortful deliberation, on condition that learners have the ability to appropriately manage their confusion, or additional pedagogical scaffolds are available" (2014, p.164). After observing the positive effects of particular states of confusion on some learners, the authors note that advanced learning technologies have the potential to improve learning. Using cognitive conflict, these technologies can provide tailored instruction for individual learners. D'Mello et al. (2014) also emphasise that before these approaches can be used in classrooms, further work is needed to clarify the exact conditions in which confusion can be employed to improve learning.

Research related to motivation has also focused on game-based learning, especially mobile game-based learning. When people play games, they can become completely engaged and immersed, reaching a state of total absorption referred to as 'flow' (Csíkszentmihályi, 1990). Immersion can be perceived as the highest state of motivation, suggesting high levels of intrinsic motivation.

One of the important studies in this area is Malone and Lepper's (1987) work on the links between intrinsic motivation and learning. They proposed seven factors to promote intrinsic motivation: challenge, curiosity, control, fantasy, competition, cooperation and recognition. As technology has the potential to immerse users into a mixed reality environment, it can also provide highly motivating learning environments (Schwabe and Goth, 2005). In her review of game-based learning, games and simulations, de Freitas (2006) concluded that these environments have substantial promise for learning but there are still challenges – such as the setting and assessment of learning objectives to ensure that game-based environments do result in learning.

Feedback

Providing feedback to learners is generally regarded as one of the most influential teaching approaches to improving knowledge and skills – particularly if it is regular, balanced and accessible. Feedback is defined by Shute (2008, p.154) as "information communicated to the learner that is intended to modify his or her thinking or behaviour for the purpose of improving learning."

However, feedback might also have negative effects on learners' motivations. For example, a learner who has received a poor grade for an assessment may withdraw from learning, preferring to opt out of further assessments rather than perform badly in them. This might lead to the learner being labelled as lazy instead of requiring support.

By providing feedback that focuses on how learners should improve their work, teachers can encourage them to feel that they are making progress. Although the results from multiple studies are not quite black and white, many educational researchers agree that providing feedback enhances learning.

In her influential review, Shute (2008) emphasises that providing feedback and delivering it correctly are shown to support learning. Another seminal work by Hattie and Timperley (2007) places feedback strategies among factors that bring about significant improvements in learner outcomes. They argue that

> "feedback is the information provided by an agent (e.g. teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding. A teacher or parent can provide corrective information, a peer can provide an alternative strategy, a book can provide information to clarify ideas, a parent can provide encouragement, and a learner can look up the answer to evaluate the correctness of a response. Feedback thus is a 'consequence' of performance" (2007, p.81).

Edtech tools can also be used to provide this type of high-quality feedback. However, it is important to note that feedback can have both a positive and a negative impact, thus the content of the feedback and the way that it is provided must be carefully considered.

Research findings emphasise the many ways to deliver feedback effectively. Wiggins (2012) notes that helpful feedback that will lead to improved learning is:

- Goal-referenced
- Tangible and transparent
- Actionable
- User-friendly (specific and personalised)
- Timely
- Ongoing
- Consistent

Many researchers reiterate these recommendations. Nicol and Macfarlane-Dick (2006) offer seven principles of feedback to promote self-regulated learning, each supported by evidence from research. These are:

1. Clarify what good performance is
2. Facilitate self-assessment
3. Deliver high quality feedback information
4. Encourage teacher and peer dialogue
5. Encourage positive motivation and self-esteem
6. Provide opportunities to close the gap
7. Use feedback to improve teaching

The 'Innovating Pedagogy' report (Sharples et al., 2012) presents examples of the ways that technology can be employed to assist each of these principles. For example, providing learners with interactive walk-throughs of successful solutions to problems will show examples of good performance.

Immediate automated responses to students' work using technology, such as latent semantic analysis, is also possible. This can be achieved by processing "a corpus of text (such as previous student work over a range of marks, or a set of model answers) to uncover similarities in meaning between words and phrases… to simulate human judgements of the coherence and style of a new piece of student writing" (Sharples et al., 2012, p.13).

Presenting learners with visible indications of their performance and progress over time, their level of achievement, and their performance in relation to peers, may motivate them in the same way that computer games can – although the authors add that such methods should be used with caution:

> "They cannot provide the precision or the insight of a human response and there is a danger that giving continual feedback will channel a student into continually adjusting performance to match the response, rather than planning and then engaging in a fluent piece of work. Rather than the student just viewing the feedback or learner model, a more useful approach may be to have the student and the system (and in some cases a human tutor) cooperate to produce an agreed representation of the student's skill, knowledge and performance. In this way the student takes a more reflective approach to self-regulation and managing feedback" (Sharples et al., 2012, p.13).

Shute (2008) suggests a number of research-based recommendations for providing feedback effectively. These are valid for both traditional and technology-enhanced learning environments (see Table 2).

Table 2 Guidelines regarding the DOs and DON'Ts of providing formative feedback (adapted from Shute, 2008, pp.177-179)

	Guideline for providing feedback	**Further explanation**
DO	Focus on the learner.	Address specific features of the learner's work in relation to the task, with suggestions on how to improve.
DO	Provide elaborated feedback and present it in manageable units.	Describe the what, how, and why of a given problem. Present feedback in small increments to offer the possibility to control for mistakes and give learners sufficient information to correct errors on their own.
DO	Be specific and clear.	Unclear messages impede learning.
DO	Keep feedback simple.	Simple feedback is generally based on one cue (e.g. verification or hint) and complex feedback on multiple cues (e.g. verification, correct response, error analysis).
DO	Reduce uncertainty between performance and goals.	Clarify goals and seek to reduce or remove uncertainty in relation to how well learners are performing on a task, and what needs to be accomplished to attain the goal(s).
DO	Give unbiased, objective feedback.	Feedback from a trustworthy source will be considered more seriously.
DO	Promote a "learning" goal orientation via feedback.	Deliver feedback emphasising that effort yields increased learning and performance, and mistakes are an important part of the learning process.
DO	Provide feedback after learners have attempted a solution.	Do not let learners see answers before trying to solve a problem on their own.
DON'T	Do not give normative comparisons.	Avoid comparisons with other students—directly or indirectly (e.g. "grading on the curve").
DON'T	Be cautious about providing overall grades.	Feedback should note areas of strength and provide information on how to improve, as warranted and without overall grading.

DON'T	Do not present feedback that discourages the learner or threatens the learner's self-esteem.	Draws focus to the "self" and away from the task at hand (common sense but also research-supported).
DON'T	Use "praise" sparingly, if at all.	Directs the learner's attention to "self," which distracts from the task and consequently from learning.
DON'T	Avoid delivering feedback orally.	When feedback is delivered in a more neutral manner (e.g. written or computer delivered), it is construed as less biased.
DON'T	Do not interrupt an actively engaged learner with feedback.	Interruptions can be disruptive to the student and impede learning.
DON'T	Avoid using progressive hints that always terminate with the correct answer.	Hints can be facilitative, but they can also be abused. Provide provisions to prevent abuse.
DON'T	Do not limit the mode of feedback presentation to text.	Exploit the potential of multimedia to avoid cognitive overload due to modality effects.
DON'T	Minimise use of extensive error analyses and diagnosis.	These do not provide sufficient benefit to learning and are only helpful in a subset of cases.

The timing of feedback is another important consideration, as the benefits of feedback can differ depending on the type of task, and the level of learner achievement. Research studies have shown that both immediate feedback (feedback given immediately after a learner has responded to a question, task or a test) and delayed feedback (feedback given some time after the completion of task or test) can be beneficial. Immediate feedback can prevent the development of misconceptions. Delayed feedback can enable misconceptions that may have emerged to be addressed substantively. To this end, Shute (2008) presented some recommendations regarding the timing of feedback in relation to different learner characteristics. She concludes the following guidance on the timing of feedback:

1. **Design the timing of feedback to align with desired outcome**. Immediate feedback can help fix errors in real time, producing greater immediate gains, whereas delayed feedback has been associated with better transfer of learning.

2. **Use immediate feedback for difficult tasks**, at least initially, so that the learner does not get bogged down and frustrated.

3. **Use delayed feedback for relatively simple tasks**, to prevent feelings of feedback intrusion and possibly annoyance.

4. **Use immediate feedback for retention of procedural or conceptual knowledge**, even for tasks requiring motor skills.

5. **Use delayed feedback to promote transfer of learning**. In relation to learner characteristics, the feedback provided may be adjusted for high-achievers and low-achievers to best facilitate understanding.

For higher-achievers:

a) Consider using delayed feedback as they may construe a moderate or difficult task as relatively easy and benefit from delayed feedback.
b) Use facilitative feedback that challenges them, such as hints, cues and prompts.
c) Permit learners to proceed at their own speed. Verification feedback may be sufficient for high achievers.

For lower-achievers:

a) Use immediate feedback in learning new tasks, as they may need the support with difficult tasks.
b) Use scaffolding by providing structure and early support.
c) Use corrective (or directive) feedback, as hints may not be as helpful as more explicit feedback.
d) Use correct response and some form of elaboration feedback.

In addition, Shute recommends: "if students are oriented more towards performance (trying to please others) and less towards learning (trying to achieve an academic goal), provide feedback that is specific and goal-directed. Also keep the learner's eye on the goal" (2008, p.181).

In the Cyberlearning Report (Roschelle et al., 2017), one of the studies related to providing feedback for teaching assistants. In the project entitled 'Teaching intercultural competence through personal informatics', Ogan and her colleagues (2017) explored ways of providing teaching assistants within higher education fast, accurate feedback on their own classroom performance (as teachers) in order to help them learn. They found that the design innovation of introducing brief but frequent messages, giving suggested teaching strategies, led to greater levels of self-efficacy.

In summary, these studies show that well-designed, timely feedback will help facilitate learning in technology-enhanced learning environments.

Mindsets

It is widely believed that a student's mindset is a critical factor that impacts on their problem-solving behaviour and attitude to taking on challenges. The construct of 'mindset' is disseminated widely by Carol Dweck, a Stanford University psychologist, who argues that people view intelligence in two different ways. The first is to believe that intelligence is inherent and fixed (i.e. fixed mindset). The second view is of a growth mindset, which is changeable and can be developed through effort and perseverance.

In an interview given to OneDublin (2012), Dweck described fixed mindset and growth mindset in educational contexts: "In a fixed mindset, students believe their basic abilities, their intelligence, their talents, are just fixed traits. They have a certain amount and that's that, and then their goal becomes to look smart all the time and never look dumb. In a growth mindset, students understand that their talents and abilities can be developed through effort, good teaching and persistence. They don't necessarily think everyone's the same or anyone can be Einstein, but they believe everyone can get smarter if they work at it."

As students with a growth mindset are more motivated to take on challenges and learn (Blackwell et al., 2007), it makes sense to incorporate growth mindset strategies within students' learning interactions.

It is widely believed that praising a student's intelligence is not the best way to help their learning. Mueller and Dweck (1998) observed that students who were praised for their intelligence were less likely to persist in a task, to perform well, or to enjoy a task than students who were praised for effort in the same situation. Dweck emphasises that to nurture the growth mindset in a classroom, students should be praised for their efforts during specific learning processes, rather than as a result of some proxy measure of their intelligence (such as test scores).

Related research findings also recommend that teachers should support students to think differently, to take on learning challenges, and to use new problem-solving approaches to develop their skills (Yeager and Dweck, 2012). This can be achieved by providing a challenging and non-repetitive classroom environment with opportunities for students to take up new tasks, develop new strategies, and learn productively from their failures (Dweck, 2010).

Kearney (2018) reviewed studies of growth mindset interventions to establish whether or not they improved students' academic attainment. Common findings were that some participants benefited from the intervention, according to at least one measure of academic attainment. In some studies, the benefits were limited to a specific group of participants. For example, Paunesku et al. (2015, cited in Kearney, 2018) found that interventions benefited students with a low grade point average (GPA), or those who had failed at least one core subject. In two other studies (Blackwell et al., 2007; Yeager et al., 2014), all participants were described as low-achieving students. As a result, Kearney concluded: "the majority of the evidence into growth mindset interventions suggests that they are effective at raising attainment for pupils at risk of educational disadvantage" (p.17).

In developing learning and teaching environments that nurture a growth mindset, there may be a role for digital learning tools that are designed to provide elements of challenge, choice, and personalisation with accompanying, carefully constructed feedback.

Kazakoff and Mitchell (2017) explored what it means to have a growth mindset and how this can be supported by education technology (edtech). They listed features that can help foster the development of a growth mindset:

- **Choice over learning path and opportunities to take learning risks**

Edtech tools can be designed to allow learners to self-monitor and develop at their own pace while also providing a choice of activities that are suitable for learners with different ability levels. As a consequence, some learners can be persuaded to take risks and embark on new challenges as no hierarchical structure or entity is monitoring (or watching) their progress. This lessens their perception of the possibility of failure. The technology might facilitate educators to identify learners who avoid risk-taking/challenge and provide these learners with more support.

- **Continuing feedback on ongoing effort**

Edtech tools can provide ongoing feedback to students, acknowledging their efforts and giving them immediate, real-time reinforcement after taking on a new challenging task.

- **Denotation of progress through competencies gained**

A cumulative record of a learner's activities in an edtech programme can have a big impact on "building confidence, reinforcing that knowledge is gained through effort and that deep learning is something gained overtime" (Kazakoff and Mitchell, 2017, p.4). There is also the possibility of using this data as a discussion focus between the teacher and the student.

- **Personalised material that challenges and engages students**

Edtech tools provide opportunities for students to challenge themselves and find out what they know (or do not know) about a concept/topic. Learners who master the concept can then move onto the next level and others can be given additional practice or further teaching. This enables all students to start at a level of optimal challenge, avoid feeling overwhelmed, and preventing them from coasting through the material without exerting any real effort.

- **Continuous opportunities for individual practice with mechanisms for teacher support**

Kazakoff and Mitchell (2017) note the commonly-used analogy when discussing mindsets that "the brain [is] a muscle that needs exercise. If students do not lift heavy weights (i.e. face challenges) their brain cannot grow" (2017, p.5). Edtech tools are well-placed to provide learners with challenges, scaffolded to their own skill level, and opportunities to try different approaches/strategies with personalised, timely feedback. There is also the facility to alert teachers if a student is continually struggling, so that additional support can be provided.

- **Fostering supportive classrooms and school-to-home connections**

To provide an environment in which a growth mindset is the norm, teachers and students need to collaborate. Edtech can help by providing a platform for students to talk about their task progress and objectives. There should be opportunities to celebrate others' successes, as well as for reassurance and peer mentoring. Students can share the data with their parents to reinforce the importance of a growth mindset approach.

Conclusion

This document provides a brief review of motivation, feedback and mindset constructs in education and presents evidence-based practical suggestions for edtech designers. It aims to explain how taking motivation, feedback and mindset into consideration when designing learning experiences can enhance the efficacy and impact of edtech tools, shaping the design and development approach.

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