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The power of internal feedback: exploiting natural comparison processes

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ABSTRACT

Students generate internal feedback by comparing their current knowledge against some reference information. That information might be planned for by teachers – usually as comments on students' performance – although most information is accessed by students themselves during task engagement, from their interactions with others, with resources and from memories of prior performances. Nearly all research on feedback in higher education focuses on comments as the comparison information. Ongoing and natural feedback comparisons with other information sources have been neglected: hence their potential for learning remains unexplored. To unlock the power of internal feedback, teachers need to have students turn some natural comparisons that they are making anyway, into formal and explicit comparisons and help them build the capacity to exploit their own comparison processes. To envision the possibilities, I present a new model of how students generate internal feedback as they self and co-regulate their learning, using information from multiple sources. I also synthesise two bodies of research to show how comparisons with different kinds of information, singly and in combination, can alter the nature and quality of the internal feedback that students generate. This lens of comparison changes everything. It calls for a fundamental shift in feedback practices and research.

KEYWORDS

Assessment; internal feedback; comparison processes; self-regulation; reference information

Introduction

In higher education, when we think about feedback, we normally think about the formal and explicit comments that someone, usually a teacher, provides to students about their academic work. The idea is that students will use those comments to improve their knowledge and understanding of that work, and that this will lead to improvements in future work. However, comments alone do not lead to improvements in learning or performance, unless students *compare* them with their own work and generate internal feedback out of that comparison (Nicol, 2019). It is this internal feedback that students use to update their knowledge and understanding and to make performance improvements (Butler and Winne 1995; Nicol and Macfarlane-Dick 2006). This is the case whatever the comments: a judgement of performance, a recommendation, a reader response, a noting of strengths or weaknesses. Hence, the following is the definition of internal feedback that frames this article:

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> Internal feedback is the new knowledge that students generate when they compare their current knowledge and competence against some reference information.

The important concepts are that feedback is always internally generated; it always involves a comparison; and that what students generate depends on the knowledge and competence they start with, which is usually instantiated in a task performance, and what they compare that performance against. This definition applies to any feedback context and not just to teacher comments. For example, musicians learn to become better musicians by comparing their compositions and performances against those of other musicians, and by generating internal feedback out of those comparisons. Similarly, scientists become better scientists by comparing their theories, methods and findings against those of other scientists. While I am not claiming that comparison is the only process at play in the generation of internal feedback, I do claim that it is essential and plays a crucial role.

Students are making comparisons all the time

In academic settings, whenever students engage in a learning task or produce some work (e.g. an assignment) they make comparisons with many different sources of information in the environment. This is an ongoing and pervasive process that informs them about how their current performance relates to their goals and what adjustments to make. For example, if they identify a gap in their understanding while producing some work, they might turn to a textbook explanation, or return to some specific information provided by the teacher (e.g. task instructions, criteria, a rubric, information in the course handbook) or talk to their peers or look at their peers' work, or go online and search for relevant resources, or return to something they have produced themselves beforehand (e.g. lecture notes, prior work). Each of these information sources might serve as a referent for comparison and for the generation of internal feedback. That students make such comparisons is hardly in doubt despite, with few exceptions, the lack of research on this topic. Otherwise, how do students regulate their performance before the receipt of comments from teachers, given that these are infrequent and usually only occur *after* the completion of a task?

One exception in the research, that throws some light on ongoing information comparisons, is a study where education students were asked how they self-assessed their work during its production (Yan and Brown 2017). As well as mentioning a range of external resources (e.g. formal criteria, past examination papers, discussions with peers), these students also mentioned retrieving ideas from memory to self-assess their performance, for example, recollections of prior performance, and even more abstract constructions such as the 'standards they had internalised from relevant previous tasks' (p1253) and their own intuitions and feelings. Similarly, in another atypical study, where medical students were asked how they self-assessed their performance during clinical placements, they reported drawing on a wide range of external (e.g. clinical practice guidelines, audits, readings, patient records) and internal information (e.g. feelings of confidence or discomfort) (Sargeant et al. 2010). Much of this information emerged through observations of, and discussions with others (e.g. patients, peers, health professionals, consultants) during ward rounds. While comparisons with information in memory, with feelings, and with external resources are ongoing and a natural part of task engagement, this mix of information would most likely change over the timeline of an academic performance, as it would depend on the stage of the task and on the availability and perceived value of different information sources.

A further finding in both these studies was students' reports that they calibrated their own performance using information from multiple sources, some of which was internally generated with other information externally sourced. In effect, comparisons with different information sources are not isolated events, they overlap in time and are also cyclic in that the outputs of earlier

comparisons (i.e. the changes in knowledge and beliefs that these comparisons entail) will change the nature of subsequent comparisons.

In this article, I provide a conceptual model showing how external information and internal feedback interact in the self- and co-regulation of learning, and the role of comparison as the hub for this interaction. I provide evidence for the model by synthesising research from two different domains. Based on this, I explore the merits of building on students' natural capacity to make feedback comparisons. Teachers need only to have students turn some comparisons that they might make anyway against external information sources into formal and explicit comparisons, and help raise students' awarness of their own capacity to exploit natural comparisons. While the focus here is on feedback in higher education what I propose has relevance across all levels of education, and even beyond education.

Internal feedback, comparison and the self- and co-regulation of learning

A conceptual model

Figure 1 is a model of the role of comparison and internal feedback generation in the self and co-regulation of learning. The model demarcates the internal mental environment, and the processing activities that take place therein, from things that happen and the information that is available in the external environment. However, in line with almost all learning theories the assumption is that the internal and external world are inter-connected and inter-dependent in thinking and action, and that students' current internal knowledge and beliefs will have been constructed out of earlier material and social interactions (e.g. Piaget 1976; Vygotsky 1978; Sfard 1998).

To exemplify how internal feedback is created out of external interactions the model shows the sequence of activities that occur as students engage in an academic task as set by a teacher, although the model equally applies to scenarios where students determine their own goals in the absence of teacher direction (e.g. when studying for an examination). Based on the task

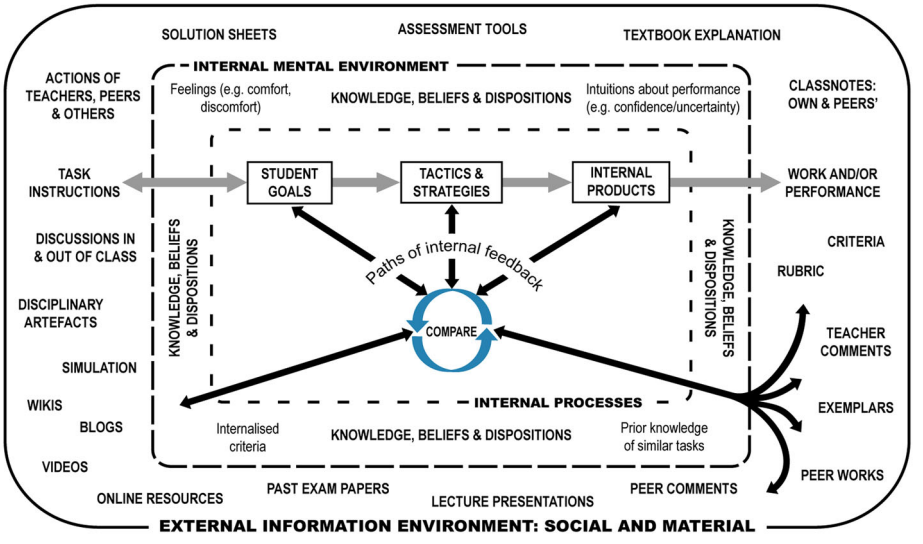

Figure 1. A model showing comparison as the mechanism for internal feedback generation and for the self- and co-regulation of learning.

instructions provided by the teacher (external information), students formulate goals and plans for accomplishing a task (internal construction). These goals are based on some mix of the student's own personal goals, moderated by their prior knowledge, beliefs and dispositions, their experience with similar tasks, and their interpretation of the task requirements. This wider interpretative process is depicted by the arrow from task instructions which passes through knowledge, beliefs and dispositions. Goals help shape the tactics and strategies that students mobilise to generate products, internal and external. Internal products refer to changes in cognitive and affective/emotional states that occur during task engagement (e.g. increased understanding, changes in self-perceptions of ability). External products refer to tangible outputs such as an actual work and/or performance (e.g. a presentation, a surgical procedure).

As students compare their unfolding work with their goals, and the tactics and strategies they have activated for their realisation, they generate internal feedback. It is this internal feedback, both about content and process, that helps students determine whether current modes of engagement should continue or if some type of change is necessary. Importantly, in the model, these comparisons against goals are not the only comparisons in play during task engagement. When students detect a discrepancy between current progress and desired goals, they will also draw on other internal information, both cognitive and affective, and on relevant external information in the environment (e.g. they may check an explanation in a textbook or talk to their peers or both) to help them move toward their goals. It is how students use external information to generate internal feedback that is the subject of this article.

External information for comparison

Figure 1 illustrates a range of possible sources, types and examples of external information that students might use for comparison. However, it is important to note that this information should not always be regarded as artefacts, just lying around in the environment waiting to be processed and used for comparison. Rather the information that students use for comparison also emerges naturally from their interactions with people and/or resources. For example, as they are listening to a lecture or reading a book, they might find themselves comparing what is being said or read against their current thoughts about an assignment they are preparing and generate feedback about how to improve the assignment out of that comparison. In this case the information for comparison is emergent and derives from what the student perceives as relevant to the task in hand. Also, what is available and relevant will depend on the discipline, the learning task and environment, the student's own goals and personal situation, their access to technology, and so on. Figure 1 is therefore just one possible depiction of the actual information environment; for example, a medical student will draw on different information from a student studying business or engineering.

A further point of note is that dialogue (or discussion) is also viewed and depicted in Figure 1 as an information source for comparison. Essentially, through dialogue, students make comparisons of their own thinking about their work with that of others and generate internal feedback about their thinking and about their work from those comparisons (Askell-Williams and Lawson 2005). This is different from other conceptions in the feedback literature, which usually posit dialogue as the means by which students make sense of the feedback that others, usually teachers, provide (e.g. Nicol 2010; Carless and Boud 2018).

Comparison processes and internal feedback generation

In the model, comparison is conceived as at core an internal process, even when it is fuelled by external information. One view of this process is that external information must be interpreted, that it is filtered by the student's own cognitive system before being used for comparison.

Another more plausible and integrative view is that the comparison process emerges from and is a product of an interaction of prior knowledge, beliefs and dispositions with current perceptions of external information.

A key feature of the model is that during the performance of a task, there are many cycles of comparison with each cycle calling on different sources of information, internal or external, to fuel them. These cycles are recursive, meaning the outputs of one cycle shapes student's developing knowledge which in turn informs the comparison processes that occur in subsequent cycles. Also, it is highly unlikely that students are using a single source of information for comparison during a task; there would always be multiple sources, some internally constructed and others externally sourced. The interpretation of one information source would invariably call on others, and to an extent each would be used by students to help them calibrate their performance and output, as suggested by Yan and Brown's (2017) students.

The internal feedback that students generate, from making comparisons of their unfolding work with external information, might lead to reinterpretation of the task, and/or adjustments of internal goals or a change in tactics or strategies. This would, in turn, lead to modified or new internal knowledge constructions and external products and to improved performance. As these changes are in train, they will also result in students revising their domain knowledge and beliefs, which will change subsequent processes of self-regulation. For example, students might fill knowledge gaps, restructure current knowledge, and/or construct new knowledge, modify existing mental models (Nicol 2013) or become more or less confident about their ability to complete the task.

Scope of the model

The feedback model depicted in Figure 1 does not just apply to scenarios where students are engaging in an academic task or when they compare external information against a finished task. It also applies to the internal feedback that students generate when planning a task. For example, in planning academic work, students compare their interpretation of the task instructions given by the teacher (external information) against their current knowledge regarding their ability to perform tasks of that kind. Out of this comparison they generate internal feedback about how to approach the task

Although this article does not directly address comparisons of work with purely internally generated affective, motivational or cognitive information, these can be accommodated by the model and are depicted by the arrow showing that learners might compare their developing thinking and work with beliefs and dispositions as well as with prior knowledge. For example, a medical student might have a vague sense that something might be wrong (i.e. a feeling of discomfort), when carrying out a task, a feeling that is also an important source of information for comparison (Sargeant et al. 2010).

In sum, the model in Figure 1 shows that students' ability to self-regulate is both constrained and facilitated by the social and material environment in which they operate as well as by their own internal knowledge, beliefs and dispositions. From this perspective, external information can only have an impact on internal feedback generation to the extent that students pay attention to it, interact with it, and make comparisons against it. In other words, external information only provides 'affordances' for comparison; it is not an assurance of internal feedback.

Cognitive research on comparison

One compelling reason for invoking comparison as the mechanism for internal feedback is the considerable cognitive research that already exists showing that comparison is 'one of the most integral components of human thought' (Goldstone, Day, and Son 2010, 103). Comparison

underpins memory processes, categorisation, decision-making, problem-solving and inference (Gentner, Holyoak, and Kokinov 2001; Goldstone, Day and Son. 2010). This research also shows that there is considerable merit in harnessing comparison as a pedagogical tool to promote higher-order thinking and reasoning (Rittle-Johnson and Star 2011; Alfieri, Nokes-Malach, and Schunn 2013). Comparison, it appears, is a process that can be developed as well as a process that promotes learning and development. Yet despite its 'fundamental role in almost everything we do' (Goldstone, Day, and Son 2010, 103) for some inexplicable reason comparison has never been theorised or systematically researched in the feedback domain.

Comparison promotes abstraction and transfer of relational structures

Most research from cognitive psychology on comparison as an instructional process intended to improve higher order cognition has focused on scenarios in which students compare two or more similar and complex cases or examples in order to determine what they have in common. For example, they might compare two case studies in business (Loewenstein, Thompson, and Gentner 1999, 2003), two worked out mathematical solutions (Rittle-Johnson and Star 2011) or two videos in education (Nagarajan and Hmelo-Silver 2006). The term used for such similar example, case or situation comparisons is *analogical comparisons* (Gentner 2010).

The reason for this focus on analogical comparisons is that learning in all spheres of education critically depends on the students' ability to notice and draw similarities at a deep structural level across different examples, cases or situations (Gentner and Maravilla 2018). Using examples or cases to teach concepts and problem-solving methods is a mainstay of classroom teaching; examples are concrete and more easily understandable than descriptions of principles or relational concepts. Yet students' learning from examples varies widely in its effectiveness. Research shows that they often fail to identify the shared principles and relational structures underpinning different examples, when it would be profitable to do so (e.g. to recognise the common solution structure across problems that differ in surface details), or they fail to access and transfer the schema they have derived from earlier comparisons to inform their understanding in new situations (Gentner, Loewenstein, and Thompson 2003; Kurtz, Boukrina, and Gentner 2013). Hence, cognitive researchers have spent considerable effort investigating how to help students better abstract the common relational schema (e.g. causal patterns, principles, contingent relationships) that underpin different examples.

Making the comparison process explicit is critical to learning from comparisons

The most critical finding from comparison research is that, although the making of analogical comparisons is natural and fundamental to human thinking and reasoning, to harness its power as a learning tool the comparison process must be made explicit (Gentner, Loewenstein, and Thompson 2003; Alfieri, Nokes-Malach, and Schunn 2013; Hoyos and Gentner 2017). The more deliberate and mindful the comparison the more likely it is that students will see beyond surface-level differences in examples or situations and encode their shared relational structures. Studying two examples one after the other, even deeply, does not guarantee this (Gentner, Loewenstein, and Thompson 2003). Students must directly compare the examples or cases. Prompts, for example, asking students to identify similarities across the items being compared, increase the depth of relational encoding and the likelihood of learning transfer. Asking for a written explanation leads to deeper relational encoding than merely asking students to make a comparison (Kurtz, Miao, and Gentner 2001). A written explanation is also recommended because creating an explanation recruits a complementary and reinforcing comparison process in which students compare the validity of their explanation against the items being compared (Edwards et al. 2019). Furthermore, in using language to explain the relational structures they identify

through comparisons, students' learning from them is more robust and portable to new contexts (Gentner 2016). Essentially using relational language enhances relational reasoning and promotes the capacity to apply knowledge across contexts.

Other findings from comparison research

Another critical finding from research is that what students learn from a comparison is determined by the nature of the items they are comparing (Goldstone, Day, and Son 2010; Lin-Siegler, Shaenfield, and Elder 2015). Also, when students compare similar items, they make inferences from one item to the other, thereby enriching their understanding of both (Kurtz, Boukrina, and Gentner 2013). Importantly, comparison research shows that schema abstraction and transfer occur, at some level, even when neither case is well understood (Kurtz, Miao, and Gentner 2001; Gentner 2010). That deliberate analogical comparisons help develop abstract and relational thinking and promote transfer has been shown across all ages of students and across many disciplines (Rittle-Johnson and Star 2011; Alfieri, Nokes-Malach, and Schunn 2013).

Implications of comparison research for internal feedback processes

The cognitive research on comparison has important implications for internal feedback processes. It suggests that analogical comparisons might be critical to the productive activation of internal feedback, feedback that would help students develop their conceptual knowledge and their ability to reason abstractly. It also suggests that the internal feedback that students generate will vary depending on what they compare their work against. Critically, comparison research makes it quite clear that making the outcomes of analogical comparisons explicit is essential to harnessing relational and principle-based learning, and to maximising the likelihood of transfer to new contexts. This is also arguably true for what I will refer to in the rest of this article as *analytic* or *analytical comparisons* (e.g. comparisons of students' work with comments, a rubric, criteria, a list of points). Indeed, a pervasive theme in recent feedback research, is that if students are to benefit from teacher comments, they must deliberately reflect on and process them, and have opportunities to apply what they learn from them in subsequent tasks (Boud and Molloy 2013; Evans 2013; Nicol 2013).

The focus of cognitive research on analogical comparisons differs from but overlaps with the feedback comparisons of interest in this article. In comparison studies, students *compare two or more external cases* to derive their common relational structure, while in feedback comparisons they *produce some work and then compare* it against some reference information. That information might be analogous (e.g. similar in format) to the student's own work or it might be specific information about that work (criteria or information about its quality) or different combinations of either or both (see Figure 1). Hence feedback comparisons are wider than purely analogical comparisons. However, feedback comparisons inevitably build on the schema derived from earlier analogical comparisons and will often themselves activate external analogical comparisons (e.g. when students compare their own work against two external similar works), so a strict separation is difficult. From this wider viewpoint, it is just as surprising that comparison researchers have not studied feedback comparisons as it is that comparison has not been theorised nor researched in the feedback domain.

Feedback studies and comparison processes

While there are no published studies, as far as I know, of internal feedback as the outcome of comparison processes, there are some studies that indirectly throw light on these processes, and two recent studies that provide much deeper insight. In this section, I centre the discussion

Table 1. Studies that illuminate how making comparisons enables students to generate productive internal feedback.

Design	Comparators	How made explicit	Measures and Findings
Nicol, Thomson, and Breslin (2014)			
1st year engineering students created a design report and reviewed the reports of two peers and received comments from peers.	(i) designs of peers (ii) comments from peers	Students given opportunities to update their work after reviewing and after receipt of comments. Asked to explain how they learned when reviewing	Improved peformance and Self-reports (i) Students said that during reviewing they compared own designs with those of peers and generated new ideas about their own work (ii) that they made three different kinds of comparison, but all were anchored back to own work (iii) that they learned different things from reviewing than from receipt of comments.
Lipnevich et al. (2014)			
2nd year psychology students produced a draft research report, and some were given a rubric, others 3 exemplars and still others both the rubric & exemplars to use to improve grades	(i) rubric (ii) exemplar (iii) rubric & exemplar.	Incentive to make comparison was to improve in grades.	Improved performance Students in all three groups improved from draft to redraft. Rubric was superior to exemplars and rubric & exemplars combined. However, students perceived exemplar as most helpful for their learning
Chi, Roy, and Hausmann (2008)			
Students solved a complex physics problem alone or in pairs. Video of a student being coached while solving the same physics problem available as a resource for consultation	(i) video of student being coached (ii) dialogue with peer	If students got stuck while working alone or in pairs, they could access the video recording to move forward.	Improved performance Students who worked in pairs in subsequent related but different physics problems shown to have learned as much as student in coaching video and more than student working alone.
Nicol and McCallum (2020)			
1st year Accountancy and Finance students wrote 500-word essay and reviewed essays of two peers plus one high-quality essay from previous cohort	(i) essays of peers (ii) comments from peers	After each peer review students asked to compare each peer essay with own essay and write account of internal feedback on own essay.	Written account of internal feedback (i) Self-feedback built up across the three review comparisons (ii) comparison with comments did not add much (iii) students produced better quality internal (self) feedback than teacher provided (iv) when compared and ranked all essays including their own students generated very high-level feedback.
Nicol and Selvaretnum (2020)			
3rd year Economics students, during an exam, wrote an evaluation report then wrote the same report again in groups of three	(i) discussion with peers (ii) unfolding group report.	After indivdual & group stage students asked to write out what they learned from the group discussion (i.e. to make explicit internal feedback) This was graded as part of exam.	Written account of internal feedback (i) Students self-generated content, process and self-regulatory feedback (ii) Teacher provided less feedback and almost no self-regulatory feedback

around five studies. The intention is to further elaborate the feedback model (Figure 1) and especially the effects of different types of information comparisons on internal feedback generation. Given the absence of research on feedback comparisons, and that two of the studies I cite are not yet peer reviewed some of what I say is speculative. Nonetheless, taken together these studies, at the very least, challenge current feedback conceptions and raise new questions for research. As each study is complex, and most were not framed from a comparison perspective, I only outline the important findings below, and refer readers to Table 1 which highlights the critical features of each study in relation to the internal feedback conception.

Making the comparison process explicit

The common feature of these five studies, that warrants their selection, is that the comparison process was made explicit in some way. In one study, students reported making comparisons and were then asked to identify how and what they learned from making them (Nicol, Thomson, and Breslin 2014). In two others, students had an incentive to make comparisons either to improve their grades (Lipnevich et al. 2014) or to help them solve a problem they were working on (Chi, Roy, and Hausmann 2008). In two studies (Nicol and Selvaretnam 2020; Nicol and McCallum 2020) students were explicitly instructed to make comparisons, and to write out a self-feedback commentary on their learning from them.

Different kinds of reference information result in different kinds of internal feedback

Analogical and analytical comparisons: between and within comparison differences

The studies provide converging evidence that what students learn from feedback comparisons depends on what they compare their work against. One important dimension of this is the broad difference between analogical and analytical comparisons, which is evident in some peer review research, although it is has not to date been discussed in those terms. For example, if you ask students what they learn from reviewing the work of their peers, they usually report that they *compare* those works with their own (analogical comparisons) and generate new *perspectives* on their own work, or new *approaches* to how they might produce that work, or insights into *what constitutes standards and quality* for work of that kind (Sadler 2010; Nicol, Thomson, and Breslin 2014; Nicol 2014; McConlogue 2015; Li and Grion 2019). This finding aligns well with analogical comparison research, as perspectives, approaches and standards are all higher-order abstractions. Interestingly, students often use the word comparison when discussing their learning from reviewing. In contrast, if you ask students what they learn from the receipt of comments from peers (which calls for analytic comparisons), students usually report learning what is *missing* in their work or about how others have interpreted their work (Nicol, Thomson, and Breslin 2014; Li and Grion 2019).

Lipnevich et al. (2014) also demonstrated learning differences across analogical and analytical comparisons, although these researchers do not explain their research using these concepts. They had psychology students write a draft research report and then gave them resources to update their drafts. One group were given three exemplar reports varying in quality, but different from their own in content (analogical comparison), another a rubric (analytic comparison) and a third group the exemplars and the rubric. All three groups improved their grades from draft to redraft without teacher input, with the rubric-alone group showing most grade improvement. Despite this, students reported that the high-quality exemplar helped them more than the rubric in terms of improving their understanding, as it provided a concrete reference model. Overall these findings, although contradictory in some ways, still support the thesis of differential internal feedback from analogical versus analytical comparisons.

As well as analogical-analytical differences there are also within comparison-type differences. For example, with regard to analogical comparisons, Nicol and McCallum (2020) found that when students compare their work against a high-quality peer work, they generate different feedback (e.g. how to improve their work) from comparisons against low-quality work (e.g. what mistakes to avoid in future work). Differences in internal feedback also logically occur across different analytical comparisons, for example when students respond to comments from two different teachers.

Multiple sequential comparisons increase the power of internal feedback generation

Much richer and more powerful internal feedback, however, seems to occur when students make multiple comparisons rather than single comparisons. Nicol and McCallum (2020) had students write a short 500-word essay, then review three peer essays one after the other. After each review, the students were instructed to write a commentary on their internal feedback by answering some questions (e.g. How does this essay differ from yours? What did you learn from that difference?). This calls for *multiple sequential comparisons*. Students accounts of their internal feedback showed that it became more elaborate and detailed across the three analogical comparisons. Importantly, analytic comparisons against comments from peers (also cued for with questions), added little to the internal feedback students had already generated from the prior analogical comparisons.

Multiple simultaneous comparisons lead to high-level conceptual learning

Nicol and McCallum (2020) also called on students to make *multiple simultaneous comparisons.* After the third peer review, students were asked to rank order the three peer essays they had reviewed, including their own, in terms of their quality and to give a reason for their ranking. From this, they identified the best essay and wrote what was good about it, and then one-by-one explained why the other essays were less good. This high-level internal feedback, about how their own work fits within a quality continuum, contributes to the conceptual learning sought after by analogical comparison researchers. It is difficult to envisage how the provision of teacher comments alone would enable students to generate this kind of internal feedback.

Dialogue amplifies other comparisons but is itself a reference comparator

Chi, Roy, and Hausmann (2008) also activated *multiple simultaneous comparisons*, but with dialogue as the focus for the comparison mix. They created a video of an expert coaching a student on how to solve a complex physics problem, then had students individually or in pairs try to solve the same physics problem. When they got stuck in their attempts to solve the problem, students could refer to the recorded video dialogue. Students in pairs learned as much as the single student in the actual video coaching situation, and more than a single student using the video as reference information. The measure of learning was performance on subsequent physics tasks. An internal feedback interpretation of this result is that working in pairs allows the student to compare her thinking with that of her partner, as well as against the video resource. While these researchers do not use the term comparison or internal feedback, this research shows how both a recorded dialogue and participating in a dialogue with a peer might serve as mutually reinforcing comparators.

Multiple simultaneous comparisons and self-regulatory feedback

Nicol and Selvaretnam (2020) also activated deliberate *multiple simultaneous comparisons* with dialogue as one of the comparators. Economics students wrote an evaluation report individually and then wrote the same report in groups of three. In this method students can compare the

work they have just produced with (i) the work that the group are producing and with (ii) the discussion about that work, which happens in parallel. Hence, this method is conducive to the generation of analogical *content* feedback (i.e. the students can compare their individual report with the final group report) and analogical *process* feedback (i.e. the student can compare how they thought about and created the report with the unfolding new report and the group discussion of the same thing). Internal feedback was made explicit after the group stage by having students write answers to some questions, for example: *What did you learn about your individual report from the discussion you just had? Can you explain how you would improve your report now if you had the opportunity to do so?*

Not only did students generate content and process feedback but also *self-regulatory* feedback. Interestingly, in their groups they did not talk about self-regulation which shows that the internal feedback students generate goes beyond what is expressed in the reference information. Self-regulatory feedback refers to self-feedback about students' own thinking and planning processes (i.e. metacognitive). It is future oriented (e.g. "in future I will explore the problem from a number of different perspectives before writing a response") rather than only about the current task. When delivered by teachers as comments this is considered the gold standard for feedback (Hattie and Timperley 2007), yet in this case the students generated it by themselves.

Internal feedback and comparison: summary of implications

While research on comparison and internal feedback is sparse, the studies above yield some important insights. They provide strong evidence that different comparators, analogical and analytical, and different within-type comparators generate different kinds of internal feedback. They also confirm and extend the findings of comparison research by showing the critical importance of including analogical comparisons in our feedback designs. However, they go beyond prior comparison research by providing evidence that multiple comparisons, both sequential (one after another) and simultaneous, with different combinations of analogical and analytic comparisons, can add breadth and power to internal feedback generation. In addition, they highlight the critical role that dialogue plays as a reference comparator in its own right, but also in amplifying the power of other comparisons. From a practice perspective the findings above alongside those from comparison research provide a compelling case for moving away from a sole focus on the specific analytical comparisons (i.e. against comments) that still seem to dominate current feedback practice.

Importantly, the studies in Table 1 all show that by merely extending the scope of comparators, students are able to generate productive internal feedback without any teacher input. Two studies also show that students' articulations of their internal feedback from multiple sequential or simultaneous comparisons were actually more extensive, and at times qualitatively different from, although just as valid as, the comments their teachers wrote (Nicol and Selvaretnam 2020; Nicol and McCallum 2020). These findings provide converging evidence that, given appropriate comparisons, students can regulate the own performance without teacher comments and that doing so helps them further develop their self-regulatory abilities.

Implications for practice

Learning design considerations

Based on the arguments above and the model in Figure 1, I suggest that there are three essential requirements for the deliberate and productive generation of internal feedback. First, students must engage in a learning task and/or produce some work, although by this I do not mean a finished work, before they make planned comparisons. Active engagement with a task ensures that students possess a focal mental representation of knowledge (conceptual,

procedural, metacognitive) against which external information can then be compared. Indeed, the internal feedback conception predicts that the more time and effort students spend constructing a response to a task, the more productive the internal feedback they will generate when confronted with planned comparison opportunities. Another reason for doing some work before making deliberate comparisons is that students will have made prior comparisons of their unfolding work against task-relevant information, and so will already have generated some feedback – for example, about their successes, difficulties encountered or gaps in understanding. Then when they make formal comparisons, they will use whatever information is available to build on their successes, to resolve difficulties or to address gaps.

The second requirement for the productive internal feedback is that the teacher or someone else (e.g. students themselves) must select or construct and make available suitable reference information for comparison. Despite the need for further research, the evidence suggests that in designing for internal feedback, educators should capitalise on analogical comparisons (of both process and output) not just analytical comparisons, on multiple sequential and simultaneous comparisons not just single comparisons, and on dialogue as a universal comparator that can be wrapped around any learning activity.

The third and critical consideration in designing for internal feedback is that students engage purposefully in the comparison process at a deep level, and that the results are made explicit, for example through writing, discussion and action. Writing is especially recommended as this not only provides teachers with important information about students' learning, but it also makes explicit to students' their ability to generate feedback. In other words, it has great metacognitive potential (Nicol 2013; Tanner 2012).

Harnessing natural comparison processes

The feedback studies in Table 1 provide concrete examples of the implementation of feedback comparisons and provide one possible starting point for teachers. Speculating from these studies and based on an ongoing programme of research into comparison and internal feedback, Figure 2 is a way of visualising the internal feedback that students might generate from comparisons with some different sources of information. This figure is indicative only as the disciplinary and environmental context will determine what reference information is available. Figure 2 is not intended to depict a one-to-one mapping of external information sources and internal feedback generation as it does not distinguish the effects when information sources are combined, or the moderating effects that different tasks or comparison instructions might have on internal feedback generation. Instead, it shows a range of internal feedback possibilities as inferred from research so far, and as such it might serve as an initial framework for implementation or for research.

The basic idea is that teachers have their students complete some work, then compare that work against one or, better still, more comparators (e.g. exemplars, a rubric, the work of peers, a video) and make the results explicit in some way. For example, they might produce a conceptual explanation at the end of a lecture class, and then compare that explanation with that of a peer as well as with a published textbook explanation, and then rewrite their own explanation. Or students might make a presentation on a topic then later compare a video of their own presentation with two videos of similar presentations, or even of similar types of presentations on different topics if the intention is primarily to help them generate feedback on their presentation skills.

As well as the comparisons implied by Figure 2 there are numerous other possibilities, for example, *authentic comparators* (i.e. having students compare their own work against that produced in employment settings) or different *forms of representation for comparison* (e.g. having students solve a problem conceptually and then giving them a diagrammatic representation of

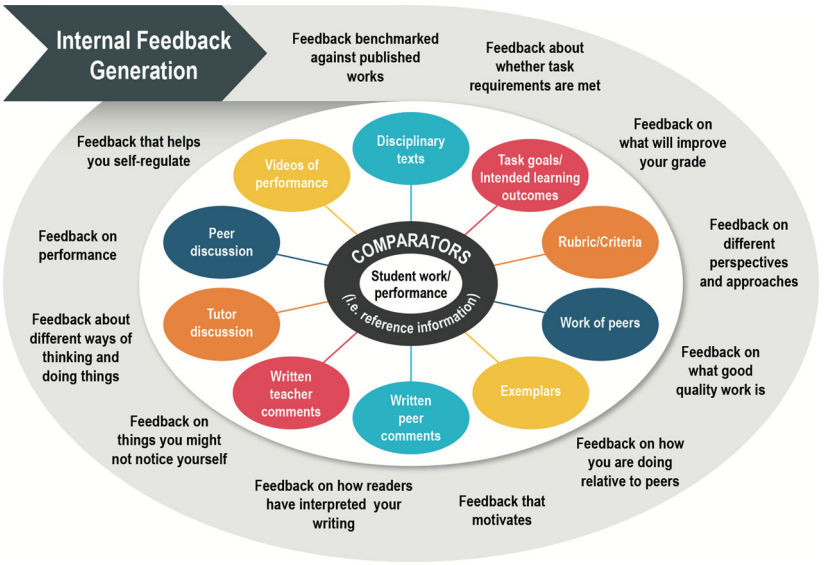

Figure 2. Different types of external reference information mapped alongside different types of internal feedback generation.

the solution to the same problem for comparison). A key consideration deriving from comparison research is that students often learn more from works dissimilar to their own in content (i.e. in surface features) but that are similar and of high quality at the deep-structural level. For example, in many circumstances it might be better to give students who have written an essay on Piaget some good quality essays on Vygotsky for explicit comparison instead of similar but better essays on Piaget. Also, essays of contrasting quality (either on Piaget or Vygotsky) might also be better as comparators than only high-quality examples (Lin-Siegler, Shaenfield, and Elder 2015). Exploring this concept of near and far comparators will prove interesting for both practitioners and researchers. Bouwer et al. (2018) provide a promising way of doing this using software that supports pairwise comparisons.

What has been discussed so far, however, really only scratches the surface of possibilities available to turn natural feedback comparisons into explicit comparisons. The reason is that many comparison opportunities only emerge through students' interactions with others and with resources in the environment. Indeed, all teachers and students will be able to identify scenarios where comparisons might happen naturally or where that was the implicit intention. For example, when students who have been working in groups are asked to present their findings in class, the unstated teacher intention might be that they compare the presentations of other groups with their own, and abstract some new ideas from those comparisons that will add to their understanding in the domain of their own work. Even if this is not the intention, students will to some extent make this comparison anyway, with or without conscious awareness. The clue to realising the latent potential of internal feedback in this, as in all other situations, is to make the comparison process explicit. This can be done, for example, by asking students to listen to other groups' presentations and to identify from them the findings or principles or recommendations that they share, and to write them down, discuss them or to say how they would use them to update their work.

Even a lecture will at times embody feedback comparison opportunities. For example, many teachers use interactive lectures where they make a short presentation, then have students complete an activity before continuing the presentation. Usually, in this setting, the lecture information provided after the activity provides opportunities for students to generate internal feedback on the learning that occurs during the activity. However, this *activity-lecture presentation* comparison could be made more productive by asking students to explicitly make it, and by

deliberately designing the lecture sequence with this in mind. Alternatively, the teacher might give students a relevant article, a pre-prepared text or play a video after the activity and ask students to compare their thinking and outputs with that, and to make a response. Or better still to compare their response with that of their peers and with the article, text or video, thus triangulating and enriching the comparisons. As these brief examples show, it is possible to build on natural comparison processes in almost any learning setting.

A further consideration for practice, important in terms of developing students' capacity to regulate their own learning, is how we can gradually shift more responsibility to them for the selection of reference information for comparison. Although this is uncharted territory, there are many ways in which this might proceed. For example, the teacher might ask students to identify a useful resource that helped them produce their own assignment and to give it to other students to compare against their assignments. Fawns and O'Shea (2019) discuss the benefits of students sharing the resources and practices through which they produce assessed work.

How this approach benefits teachers

One merit of having students make the results of their feedback comparisons explicit, is that it gives teachers very rich information about students' learning and about their self-feedback capability. This information enables teachers to better tailor subsequent comparisons to address students' unfolding needs as well as to decide when and how to target their own comments. Invariably, they will find that many of the comments they might anticipate providing will not be necessary, as students will have generated that knowledge as internal feedback by themselves from earlier comparisons. Also, after having generated their own feedback from prior comparisons, students are likely to be more receptive to teacher comments and arguably better able to make sense of and use them. A basic recommendation is that teachers reserve their comments until after students have made comparisons against other information sources, as this will reduce teacher workload, ensure that what they provide is maximally relevant and necessary, while at the same time it will foster student independence. Another recommendation is that when teachers give comments (e.g. 'this argument is not very strong') they also provide examples (e.g. of some good arguments, even from different domains), as this will combine analytic with analogical comparisons. Finn, Thomas, and Rawson (2018) have shown how doing this improves students' concept learning from received feedback.

A further merit of this approach, with its range of comparators, is that teachers can create many more planned feedback-generating opportunities without increasing their workload in providing comments. However, this requires that they don't feel they have to respond to every comparison that students make. After all, when they give written feedback comments to students, teachers do not usually comment again after students have made comparisons of their work against those comments. Still another merit is that this approach turns internal feedback generation into a divergent and multifaceted process that results in a diversity of learning outcomes (e.g. a wider perspective on work, different approaches, self-calibration) rather than a convergent process, only targeted at raising grades (Torrance 2012).

Limitations of conceptual model and areas in need of research

There is clearly a need for substantial research and for further theory development with regard to the ideas presented in this article, given the speculative nature of some of them. Research is urgently needed on the effects of different kinds of reference information, singly and in combination, on internal feedback generation. How analogical comparisons stack up against analytic comparisons could be the starting focus for this research. However, combinations of information also require equal attention as initial studies show that sequential and simultaneous comparisons

hold most promise in terms of reducing teacher workload (in delivering comments) while also developing the students' ability to regulate their own learning. An important question here is how analogical and analytical comparisons can be harnessed in mutually supportive ways so that students learn to give expression to the relational concepts about which they are generating feedback. In this regard, feedback researchers might revisit dialogue, as viewing this as comparison information is a conceptual shift that opens up new possibilities for feedback practice.

Research is also required on how to ensure students engage with and capitalise on the comparison process itself. Relevant questions here are: what kinds of comparison instructions are most effective in ensuring that students generate productive feedback and how should we frame our instructions so as to elicit different internal feedback effects? Instructions are critical as they help shape the ways in which students explore the knowledge space (i.e. the similarities and differences) between external information and their own work, which determines the internal feedback they generate from that exploration. While comparison researchers offer some suggestions about instructions, these are quite limited and only relate to analogical comparisons (e.g. Alfieri, Nokes-Malach, and Schunn 2013).

A further consideration is how to widen the scope of disciplinary texts used as reference information for comparison and how to stage their timeline of use. For example, if teachers vary the texts that students use for comparison at different stages during the production of an assignment, different knowledge and skills could be targeted and developed. Such texts could be selected or adapted from published works or could be specially prepared by the teacher to target known areas of conceptual difficulty. Similarly, in disciplines or scenarios where improving performance is the focus (e.g. surgery, dance, theatre) there would be considerable merit in exploring how audio-visual resources and especially observations of others could be productively staged as comparators.

While this article has emphasised the wide range of possible types and sources of reference information, analogical and analytical, that might be explicitly used for comparison, it hasn't directly addressed the crucial question: *What is the specific value of teacher comments as a comparator*? To put it differently, what is so special about comments from teachers, that sets them apart from other types of information that students might use for comparison? Is it their reader response characteristics (it is almost impossible to self-select comparators for this), their special value in helping students calibrate their own internal feedback constructions, the additional information they provide alongside other comparators, that they help reveal to students blind spots in their thinking, their emotional or reassurance or authority value or some mix of these, or something else? Finding some answers to this question is perhaps one of the main challenges facing future research.

From the theoretical viewpoint, the main gap in my analysis concerns the affective dimension of internal feedback. While the internal feedback model acknowledges emotions, self-beliefs and internal states as information for comparison, I have not discussed these aspects. The literature on the emotional dimensions of feedback, however, invariably focuses on the negative or defensive responses that students exhibit when they receive comments from teachers (Rowe 2017; Ryan and Henderson 2018) or from peers (Kaufman and Schunn 2011). One would expect therefore that such defensiveness might be diminished when the comparison focus is shifted from comments to material resources, although other emotional issues might then emerge, for example, about students' confidence in their ability to make productive comparisons. In my own work, I have found that students do need reassurance, at least at first, about their own feedback capability. However, this is another unexplored area that warrants a whole programme of research.

The internal feedback model and other conceptual models of feedback

In this section, I discuss how the conceptual model of feedback proposed in this article relates to the conceptions and models that frame current research. In terms of this focus, I divide

current research on feedback into two broad strands: (i) pedagogical research on formative assessment where feedback is conceived as a communication or dialogical process and (ii) research on self-regulated learning where feedback is conceived as the outcome of an internal mental process by which students regulate their own learning. The differences across these research strands have been outlined by Panadero, Andrade, and Brookhart (2018), who also note a current fusing of ideas, with some writers now spanning both strands.

Feedback as a communication process

Within the formative assessment literature, feedback is viewed as a special case of a general communication process. It is the message that a sender (usually a teacher), conveys to a recipient (a student) and which that recipient uses to make improvements in her or his understanding and work (Hattie and Timperley 2007). In this conception, the message comprises information about the recipient's performance (Ashford and Cummings 1983). While in the past, the main focus of research was on the quality of the message transmitted (Natriello 1987), recent research focuses more on the need for students to engage actively with the message, to construct meaning out of it and act on it, and on the ways in which teachers might help students develop their capacity for 'active engagement' (Boud and Molloy 2013).

Ajjawi and Boud (2017, 2018), for example, contend that feedback is a *dialogue*, as for the student to make sense of the feedback message, and to understand it in the way the sender intended, requires (inter)action by the student as well as by the teacher (see also, Nicol 2010; Merry et al. 2013). Winstone et al. (2017) propose that we need to develop students' *feedback recipience* capability, the skills and attitudes they need to make sense of feedback information coming from others, especially teachers but also from peers. Carless (2020) suggests that we view feedback as a partnership, with the feedback message a *co-construction* by sender and receiver, the teacher and student, or by students in dialogue with each other. Boud and Molloy (2013) argue that we need to recast students as active agents in the communication process, not just waiting to receive feedback messages from others but *proactively seeking* them out. Many taking this communication conception also maintain that the students' ability to make sense of received feedback can be improved by developing their capacity to give feedback, hence the strong emphasis in the literature on engaging students in peer feedback activities (Evans 2013: Winstone et al. 2017: Carless and Boud 2018). All these ideas have coalesced into the recommendation that to improve learning from feedback messages, practical steps must be taken to develop students' *feedback literacy* (Sutton 2012: Gravett 2020) recently defined as 'the understandings, capabilities and dispositions needed to make sense of information and use it to enhance work and learning strategies' (Carless and Boud 2018, 1316).

Based on the conceptions above, one might think that this article merely gives a label - internal feedback - to what students generate when they process information received or sought from others. However, this is not all that is at stake. What is absent in these conceptions is explicit consideration of, and how to capitalise on, the feedback that students are naturally generating from their mental processing of other information (analogical and analytical) available in, and emergent from interactions with, the learning environment (e.g. from textbooks, journal articles, online videos, informal peer discussion, from observations): that is, information that is not planned for by the teacher and that does not come from planned dialogue, written or spoken, with others. Some researchers who take a proactive and dialogic perspective do discuss information sources other than comments and do recommend planning for students' interaction with them. However, the range of information sources is limited usually to exemplars, assessment criteria or rubrics (e.g. Rust, Price, and O'Donovan 2003; Panadero and Jonsson 2013; Carless and Chan 2017). More important, the concern of these researchers is with how these information sources might be used by students before they engage in a learning task to help them grasp

the requirements, rather than with how students might use this information for deliberate comparison at different stages during or after a task performance, when the feedback impact would be quite different and indeed more potent. Even researchers whose primary focus is on the quality of the comments that teachers deliver (e.g. Hattie and Timperley 2007) at times allude to other information (e.g. textbooks) as a feedback source but usually only in passing and without further analysis.

The definition of feedback literacy above actually hinges on the word *information* (Carless and Boud 2018). Yet what that information might comprise, its scope beyond comments, and how it might be used to develop feedback literacy have not been fully articulated by researchers. If those researching feedback literacy reframed this notion in terms of building the students' capacity for internal feedback generation through providing opportunities for them to capitalise on the natural information comparisons they are already making, rather in terms of helping them become better processors of received feedback from others, this would better align with their own definition. At the same time, it would stretch the possibilities for feedback literacy development. In sum, to date, information sources, other than those that occur through planned human interaction, written and spoken, with teacher or peers, have not been the subject of any systematic research in terms of their internal feedback-generating potential.

Additionally, researchers who take an interactive and dialogic perspective on feedback usually claim somewhere in their writings that students must use the information they receive from others to *close the gap* between current performance and aimed-for performance (Sadler, 1989). Closing a gap implies a comparison process as does *exploring the gap* which is more aligned with the conception in this article (Torrance 2012). Yet comparison has not been discussed as a mechanism underpinning feedback dialogue, co-construction or proactive recipience, which is surprising especially for the latter, as proactive recipience is a cognitive conception.

Internal feedback and learner self-regulation

Researchers who view internal feedback as integral to learner self-regulation usually take as their starting point Butler and Winne (1995) seminal review (e.g. Clark 2012; Winstone and Carless 2019; Panadero, Andrade, and Brookhart 2018). In that review, the then available research on feedback was synthesised to produce a conceptual model (Butler and Winne 1995, Figure 1, 248) in which internal feedback was shown as the 'inherent catalyst' for the self-regulation of learning. That model was later updated by Nicol and Macfarlane-Dick (2006) who also linked it to some principles of good feedback practice. There were, however, two important limitations in these models and the conceptions underpinning them, neither of which have been addressed in the literature on internal feedback to date. First, these researchers did not depict in their models or elaborate in their conceptions how information derived from external sources, other than that provided by a teacher, might be harnessed to improve internal feedback generation. This gap parallels that in research where feedback is framed as a communication process. Second, the mechanism for feedback generation in these models was portrayed as 'monitoring'. To quote Butler and Winne (1995): 'as learners monitor their engagement with a learning task, internal feedback is generated by the monitoring process' (p246).

This term 'monitoring' is widely used to explain the mechanism of internal feedback, probably as a result of its use by Butler and Winne (1995) in their landmark review. It might, however, have hampered the advancement of research. The term is abstract, open to interpretation and importantly it is difficult to envisage how to operationalise it as an educational strategy (e.g. how do you improve students' monitoring?). Monitoring is similar to attention: it is a necessary but not a sufficient condition for internal feedback generation. Students might monitor some external information but not actually compare it to their own work and hence not generate internal feedback from that monitoring. In any case, those using the term monitoring often

implicitly, and sometimes even explicitly, refer to comparison alongside monitoring somewhere in their writings, including Butler and Winne (1995), although they don't usually foreground it (e.g. Nicol and Macfarlane-Dick 2006; Panadero et al. 2019).

More recently, researchers who posit internal feedback as inherent in self-regulation have taken the position that the main mechanism by which it is generated is 'self-assessment', although other terms are also used, for example, 'evaluation', 'evaluative judgement' and even 'reflection', sometimes interchangeably and sometimes overlappingly (Panadero, Lipnevich and Broadbent, 2019; Panadero et al. 2019; Boud et al. 2019; Nicol, Serbati, and Tracchi 2019; Yan 2020). Andrade (2018), for example, maintains that 'self-assessment is feedback' but also states that 'monitoring and self-assessment processes are practically synonymous with self-regulated learning' (p379). Yan (2020) instead views self-assessment as a process that activates 'feedback seeking' by students, where they attempt to collect information about performance from various sources, external and or internal. External information is obtained through 'inquiry', by asking for feedback directly from others (e.g. teachers or peers) and/or through 'monitoring', by seeking out feedback through interactions with the learning environment. Internal feedback, in contrast, involves seeking 'implicit information from the self' (e.g. emotions, feelings, physical sensations and internal states)' (Yan 2020, 2).

Panadero, Lipnevich and Broadbent (2019) define 'self-feedback [i.e. internal feedback] … as … [a direct result of] … the implementation of self-assessment' (p148), without proposing any further mechanism for the self-regulation of learning, which is congruent with the model in Figure 1. However Panadero et al. (2019), in another article that explicitly updates the Butler and Winne (1995) model, propose that the mechanism underpinning self-regulation is 'evaluative judgement' which, drawing on the work of Tai et al. (2018), they define as the students' 'capacity to judge the work of self and others'. This mix of terminology for the same or overlapping mechanisms is confusing and may be another reason why research on internal feedback and its role in learner self-regulation has not had the impact it deserves.

In his book on human judgement Laming (2004) claims that 'all judgements are comparisons of one thing with another' (Laming 2004, 7–8), there is no such thing as an absolute judgement, decision or evaluation. 'Most decisions that people make are not blind choices … There is a material basis for them but not so clear that the judgement is obvious' (Laming 2004, 8). Goldstone, Day, and Son (2010) however present a more accurate picture when they state that 'comparison plays a critical role in problem-solving, judgement, decision making, categorisation and cognition, broadly construed' (p103). Comparison is not a judgement, a decision or an evaluation: rather it is prior and underpins processes of judgment, decision making and evaluation. This is actually implied by Laming's (2004) own words *there is a material basis for them*. When students self-assess or evaluate their own work, they must make a comparison with something even if what they compare their work against is not accessible to an outside observer (e.g. when it is an internally constructed image, or a notion of criteria derived from past experience).

Notwithstanding this confusion of terminology, the positions taken by the researchers above are to different degrees somewhat consistent with that in this article, especially if we acknowledge that self-assessment, evaluation, evaluative judgement and monitoring all depend on comparison processes. Goldstone, Day, and Son (2010) and Laming's (2004) argument that all judgements involve a comparison is one compelling reason for doing this. Another is that as soon as one thinks of internal feedback as the result of a comparison it fundamentally changes, and considerably expands and clarifies, one's view of what is possible in practice.

There are however some important differences between the positions above and that in this article. Most of the research on self-assessment casts it as a pedagogical method that teachers might implement with their students rather than as a natural process that is inherent in all acts of self-regulation. This has impeded appreciation of the potential that exists to exploit ongoing and natural comparison processes by making them explicit. Researchers on self-assessment also prioritise the use of assessment criteria as the comparator because the pedagogical focus is

invariably only on how to help students improve the standards of their work (e.g. Yan and Brown 2017; Andrade 2018; Panadero, Lipnevich and Broadbent 2019). This emphasis is unfortunate as it privileges analytical information over analogical information in self-assessment practice. In contrast, the position in this article is that assessment criteria are not the only or necessarily the best information for self-assessment activities, and that a blend of different types of information (analytical and analogical) might better generate internal feedback about standards, while at the same time generate feedback that goes beyond just informing students about standards (e.g. about alternative ways to approach their work, about their own self-regulatory ability). No-one who takes a self-assessment position, as far as I am aware, has tested the proposition that when students deliberately use different reference information and multiple sources of information for self-assessment activities, that the consequence is different kinds of internal feedback. This is a key argument in this article and its recognition opens up many new avenues for self-assessment practice and research.

There is also a tendency in self-assessment and in evaluative judgement research to portray teacher comments on students' self-assessments as the main or only way to help students calibrate their self-assessment judgements (e.g. Tai et al. 2018). While the value of teacher comments is not in dispute, this article takes a wider view. Students are always calibrating their judgements about performance, using information from many different sources, analogical and analytical, including comments (Yan and Brown 2017). Hence, the notion of calibration should be expanded to take account of and to capitalise on this natural propensity. A further issue concerns the way in which co-regulation is conceived, or at least portrayed, in relation to self-assessment. While Panadero, Lipnevich and Broadbent (2019) aptly note that self-assessment and hence self-feedback should not be conceived as an individual activity, as there is much to be gained by having others, teachers and peers, scaffold students' self-assessment activities, this framing of co-regulation is somewhat narrower than that taken here. Like Allal (2016), I associate co-regulation not just with 'other people' regulation, but also with 'material' regulation meaning that the structural features of the learning environment and the information contained within it are also scaffolds for comparison and for internal feedback generation.

Conclusion

The feedback students generate from the ongoing comparisons they are making of their work against information in the social and material environment is more important in determining what they learn than the planned and intermittent comparisons they make of their work against comments, from teachers or peers. Indeed, without such ongoing natural comparisons it is difficult to fully explain how students learn. In the research literature and in practice, however, there is a disconnect between informal, spontaneous and natural feedback processes and formal, planned and deliberate feedback processes. This has limited the scope of both research and practice.

By identifying comparison as the core and integrative mechanism for all feedback processes, informal and formal, spontaneous and planned, this article removes this artificial conceptual separation. It also aligns the findings from analogical comparison research with those from feedback research to show that comparison is a more universal and pervasive mental process than hitherto recognised, even by cognitive researchers.

Armed with this integrative and holistic feedback conception the possibilities for practice are vast. All teaching and learning scenarios are laced with latent comparison opportunities. Teachers need only to identify some of these comparisons and have students make them explicit. Students should also practise identifying and enacting such comparisons themselves. When they gain awareness and experience of the value of this way of generating feedback, students

will inevitably continue doing it unaided by teachers. This article calls for a fundamental shift in feedback thinking, a shift that opens up a completely new agenda for practice and research.

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References

Ajjawi, R., and D. Boud. 2017. "Researching Feedback Dialogue: An Interactional Analysis Approach." *Assessment & Evaluation in Higher Education* 42: 252–265. doi:10.1080/02602938.2015.1102863.

Ajjawi, R., and D. Boud. 2018. "Examining the Nature and Effects of Feedback Dialogue." *Assessment & Evaluation in Higher Education* 43 (7): 1106–1119. doi:10.1080/02602938.2018.1434128.

Alfieri, L., T. Nokes-Malach, and C. Schunn. 2013. "Learning through Case Comparison: A Meta-Analytic Review." *Educational Psychologist* 48 (2): 87–113. doi:10.1080/00461520.2013.775712.

Allal, L. 2016. "The Co-Regulation of Student Learning in an Assessment for Learning Culture." In *Assessment for Learning: Meeting the Challenge of Implementation*, edited by D. Laveault and L. Allal. Switzerland: Springer. doi:10.1007/978-3-319-39211-0_15.

Andrade, H. L. 2018. "Feedback in the Context of Self-Assessment." In *The Cambridge Handbook of Instructional Feedback*, edited by A.A. Lipnevich and J.K. Smith, 376–408. Cambridge: Cambridge University Press.

Ashford, S. J., and L. L. Cummings. 1983. "Feedback as an Individual Resource: Personal Strategies of Creating Information." *Organisational Behaviour and Human Performance* 32: 370–398. doi:10.1016/0030-5073(83)90156-3.

Askell-Williams, H., and M. J. Lawson. 2005. "Students' Knowledge about the Value of Discussions for Teaching and Learning." *Social Psychology of Education* 8 (1): 83–115. doi:10.1007/s11218-004-5489-2.

Boud, D., and E. Molloy. 2013. "Rethinking Models of Feedback for Learning: The Challenge of Design." *Assessment & Evaluation in Higher Education* 38 (6): 698–712. doi:10.1080/02602938.2012.691462.

Boud, D., R. Ajjawi, P. Dawson, and J. Tai. 2019. *Developing Evaluative Judgement in Higher Education; Assessment for Knowing and Producing Quality Work*. Oxford: Routledge.

Bouwer, R., M. Lesterhuis, P. Bonne, and S. De Maeyer. 2018. "Applying Criteria to Examples or Learning by Comparison: Effects on Students' Evaluative Judgment and Performance in Writing." *Frontiers in Education* 3: 86. doi:10.3389/feduc.2018.00086.

Butler, D. L., and P. H. Winne. 1995. "Feedback and Self-Regulated Learning: A Theoretical Synthesis." *Review of Educational Research* 65 (3): 245–281. doi:10.3102/00346543065003245.

Carless, D. 2020. "Longitudinal Perspectives on Students' Experiences of Feedback: A Need for Teacher–Student Partnerships." *Higher Education Research & Development* 39 (3): 425–438. doi:10.1080/07294360.2019.1684455.

Carless, D., and D. Boud. 2018. "The Development of Student Feedback Literacy: Enabling Uptake of Feedback." *Assessment & Evaluation in Higher Education* 43 (8): 1315–1325. doi:10.1080/02602938.2018.1463354.

Carless, D., and K. K. H. Chan. 2017. "Managing Dialogic Use of Exemplars." *Assessment & Evaluation in Higher Education* 42 (6): 930–941. doi:10.1080/02602938.2016.1211246.

Chi, M. T H., M. Roy, and R. G. M. Hausmann. 2008. "Observing Tutorial Dialogues Collaboratively: Insights about Human Tutoring Effectiveness from Vicarious Learning." *Cognitive Science* 32 (2): 301–341. doi:10.1080/03640210701863396.

Clark, I. 2012. "Formative Assessment: Assessment is for Self-Regulated Learning." *Educational Psychology Review* 24 (2): 205–249. doi:10.1007/s10648-011-9191-6.

Edwards, B. J., J. J. Williams, D. Gentner, and T. Lombrozo. 2019. "Explanation Recruits Comparison in a Category-Learning Task." *Cognition* 185: 21–38. doi:10.1016/j.cognition.2018.12.011.

Evans, C. 2013. "Making Sense of Assessment Feedback in Higher Education." *Review of Educational Research* 83 (1): 70–120. doi:10.3102/0034654312474350.

Fawns, T., and C. O'Shea. 2019. "Evaluative Judgement of Working Practices: Reconfiguring Assessment to Support Student Adaptability and Agency across Complex Settings." *Italian Journal of Educational Technology 27*(1): 5-18. doi:10.17471/2499-4324/1027.

Finn, B., R. Thomas, and K. A. Rawson. 2018. "Learning More from Feedback: Elaborating Feedback with Examples Enhances Concept Learning." *Learning and Instruction* 54: 104–113. doi:10.1016/j.learninstruc.2017.08.007.

Gentner, D. 2010. "Bootstrapping the Mind: Analogical Processes and Symbol Systems." *Cognitive Science* 34 (5): 752–775. doi:10.1111/j.1551-6709.2010.01114.x.

Gentner, D. 2016. "Language as a Cognitive Tool Kit: How Language Supports Relational Thought." *The American Psychologist* 71 (8): 650–657. doi:10.1037/amp0000082.

Gentner, D. G., K. J. Holyoak, and B. K. Kokinov. 2001. *The Analogical Mind: Perspectives from Cognitive Science*. Cambridge, MA: MIT Press.

Gentner, D., and F. Maravilla. 2018. "Analogical Reasoning." In *International Handbook of Thinking and Reasoning*, edited by L. J. Ball and V. A. Thomson, 186–203. New York, NY: Psychology Press.

Gentner, D., J. Loewenstein, and L. Thompson. 2003. "Learning and Transfer: A General Role for Analogical Encoding." *Journal of Educational Psychology* 95 (2): 393–408. doi:10.1037/0022-0663.95.2.393.

Goldstone, R. L., S. Day, and J. Y. Son. 2010. "Comparison." In *On Thinking: Towards a Theory of Thinking*, edited by B. Glatzeder, V. Goel, and A. von Müller, 103–122. Heidelberg, Germany: Springer-Verlag. doi:10.1007/978-3-642-03129-8_7.

Gravett, K. 2020. "Feedback Literacies as Sociomaterial Practice." *Critical Studies in Education*. doi:10.1080/17508487.2020.1747099.

Hattie, J., and H. Timperley. 2007. "The Power of Feedback." *Review of Educational Research* 77 (1): 81–112. doi:10.3102/003465430298487.

Hoyos, C., and D. Gentner. 2017. "Generating Explanations via Analogical Comparisons." *Psychonomic Bulletin & Review* 24 (5): 1364–1374. doi:10.3758/s13423-017-1289-5.

Kaufman, J., and C. Schunn. 2011. "Students' Perceptions about Peer Assessment for Writing: Their Origin and Impact on Revision Work." *Instructional Science* 39 (3): 387–406. http://www.jstor.org/stable/23882808. doi:10.1007/s11251-010-9133-6.

Kurtz, K. J., C. H. Miao, and D. Gentner. 2001. "Learning by Analogical Bootstrapping." *Journal of the Learning Sciences* 10 (4): 417–446. doi:10.1207/S15327809JLS1004new_2.

Kurtz, K. J., O. Boukrina, and D. Gentner. 2013. "Comparison Promotes Learning and Transfer of Relational Categories." *Journal of Experimental Psychology. Learning, Memory, and Cognition* 39 (4): 1303–1310. doi:10.1037/a0031847.

Laming, D. 2004. *Human Judgement: The Eye of the Beholder*. London: Thomson Learning. ISBN 1-86152-777-2.

Li, L., and V. Grion. 2019. "The Power of giving feedback ad receiving feedback in peer assessment", *All Ireland Journal of Teaching and Learning in Higher Education* 11 (2): 1–17. https://ojs.aishe.org/index.php/aishe-j/article/view/413/671

Lin-Siegler, X., D. Shaenfield, and A. D. Elder. 2015. "Contrasting Case Instruction Can Improve Self-Assessment of Writing." *Educational Technology Research and Development* 63 (4): 517–537. doi:10.1007/s11423-015-9390-9.

Lipnevich, A. A., L. N. McCallen, K. P. Miles, and J. K. Smith. 2014. "Mind the Gap! Students' Use of Exemplars and Detailed Rubrics as Formative Assessment." *Instructional Science* 42 (4): 539–559. doi:10.1007/s11251-013-9299-9.

Loewenstein, J., L. Thompson, and D. Gentner. 1999. "Analogical Encoding Facilitates Knowledge Transfer in Negotiation." *Psychonomic Bulletin & Review* 6 (4): 586–597. doi:10.3758/bf03212967.

Loewenstein, J., L. Thompson, and D. Gentner. 2003. "Analogical Learning in Negotiation Teams: Comparing Cases Promotes Learning and Transfer." *Academy of Management Learning & Education* 2 (2): 119–127. doi:10.5465/amle.2003.9901663.

McConlogue, T. 2015. "Making Judgements: Investigating the Process of Composing and Receiving Peer Feedback." *Studies in Higher Education* 40 (9): 1495–1506. doi:10.1080/03075079.2013.868878.

Merry, S., M. Price, D. Carless, and M. Taras. 2013. *Reconceptualising Feedback in Higher Education: Developing Dialogue with Students*. London: Routledge.

Nagarajan, A., and C. Hmelo-Silver. 2006. "Scaffolding Learning from Contrasting Video Cases." *Proceedings of the 7th International Conference on Learning Sciences*, 495–501.

Natriello, G. 1987. "The Impact of Evaluation Processes on Students." *Educational Psychologist* 22 (2): 155–175. doi:10.1207/s15326985ep2202_4.

Nicol, D. 2010. "From Monologue to Dialogue: Improving Written Feedback Processes in Mass Higher Education." *Assessment & Evaluation in Higher Education* 35 (5): 501–517. doi:10.1080/02602931003786559.

Nicol, D. 2013. "Resituating Feedback from the Reactive to the Proactive." In *Feedback in Higher and Professional Education: Understanding It and Doing It Well*, edited by D. Boud and E. Molloy, 34–49. Oxon: Routledge.

Nicol, D. 2014. "Guiding Principles of Peer Review: unlocking Learners' Evaluative Skills." In *Advances and Innovations in University Assessment and Feedback*, edited by C. Kreber, C. Anderson, N. Entwistle and J. McArthur. Edinburgh: Edinburgh University Press http://www.jstor.com/stable/10.3366/j.ctt14brxp5.16.

Nicol, D. 2019. "Reconceptualising Feedback as an Internal Not an External Process." *Italian Journal of Educational Research, Special Issue* : 71–83. https://ojs.pensamultimedia.it/index.php/sird/article/view/3270.

Nicol, D., A. Serbati, and M. Tracchi. 2019. "Competence Development and Portfolios: Promoting Reflection through Peer Review." *All Ireland Journal of Higher Education* 11 (2): 1–13. ojs.aishe.org/index.php/aishe-j/article/view/405/664.

Nicol, D., A. Thomson, and C. Breslin. 2014. "Rethinking Feedback Practices in Higher Education: A Peer Review Perspective." *Assessment & Evaluation in Higher Education* 39 (1): 102–122. doi:10.1080/02602938.2013.795518.

Nicol, D., and G. Selvaretnam, G. 2020. "Making Internal Feedback Explicit: Harnessing the comparisons students make during two-stage exams. https://doi.org/10.31234/osf.io/jrc6y

Nicol, D., and S. McCallum. 2020. "Making internal feedback explicit: Exploiting the multiple comparisons that occur during peer review." doi:10.31234/osf.io/ksp2v

Nicol, D. J., and D. Macfarlane-Dick. 2006. "Formative Assessment and Self-Regulated Learning: A Model and Seven Principles of Good Feedback Practice." *Studies in Higher Education* 31 (2): 199–218. doi:10.1080/03075070600572090.

Panadero, E., H. Andrade, and S. Brookhart. 2018. "Fusing Self-Regulated Learning and Formative Assessment: A Roadmap of Where we Are, How we Got Here, and Where we Are Going." *The Australian Educational Researcher* 45 (1): 13–31. doi:10.1007/s13384-018-0258-y.

Panadero, E., J. Broadbent, D. Boud, and J. M. Lodge. 2019. "Using Formative Assessment to Influence Self- and co-Regulated Learning: The Role of Evaluative Judgement." *European Journal of Psychology of Education* 34 (3): 535–557. doi:10.1007/s10212-018-0407-8.

Panadero, E., and A. Jonsson. 2013. "The Use of Scoring Rubrics for Formative Assessment Purposes Revisited: A Review." *Educational Research Review* 9: 129–144. doi:10.1016/j.edurev.2013.01.002.

Panadero, E., A. Lipnevich, and J. Broadbent. 2019. "Turning Self-Assessment into Self-Feedback." In *The Impact of Feedback in Higher Education*, edited by M. Henderson, R. Ajjawi, D. Boud, and E. Molloy. Cham: Palgrave Macmillan. doi:10.1007/978-3-030-25112-3_9.

Piaget, J. 1976. *The Grasp of Consciousness: Action and Concept in the Young Child*. Cambridge: Harvard University Press.

Rittle-Johnson, B., and J. R. Star. 2011. "The Power of Comparison in Learning and Instruction. Learning Outcomes Supported by Different Types of Comparisons." *Psychology of Learning and Motivation* 55: 199–225. doi:10.1016/B978-0-12-387691-1.00007-7.

Rowe, A. D. 2017. "Feelings about Feedback: The Role of Emotions in Assessment for Learning." *In Scaling up Assessment for Learning in Higher Education*, edited by D. Carless, S. M. Bridges, S. K. Y. Chan and R Glofcheski, 159–172. Singapore: Springer.

Rust, C., M. Price., and B. O'Donovan. 2003. "Improving Students Learning by Developing Their Understanding of Assessment Criteria and Processes." *Assessment & Evaluation in Higher Education* 28 (2): 147–164. doi:10.1080/02602930301671.

Ryan, T., and M. Henderson. 2018. "Feeling Feedback: Students' Emotional Responses to Educator Feedback." *Assessment & Evaluation in Higher Education* 43 (6): 880–892. doi:10.1080/02602938.2017.1416456.

Sadler, D. R. 1989. "Formative Assessment and the Design of Instructional Systems." *Instructional Science* 18 (2): 119–144. doi:10.1007/BF00117714.

Sadler, D. R. 2010. "Beyond Feedback: Developing Student Capability in Complex Appraisal." *Assessment & Evaluation in Higher Education* 35 (5): 535–550. doi:10.1080/02602930903541015.

Sargeant, J., H. Armson, B. Chesluk, T. Dornan, K. Eva, E. Holmboe, J. Lockyer, E. Loney, K. Mann, and C. van der Vleuten. 2010. "The Processes and Dimensions of Informed Self-Assessment: A Conceptual Model." *Academic Medicine* 85 (7): 1212–1220. doi:10.1097/ACM.0b013e3181d85a4e.

Sfard, A. 1998. "*On Two Metaphors for Learning and the Danger of Choosing Just One*." *Educational Researcher* 27 (2): 4–13. doi:10.2307/1176193.

Sutton, P. 2012. "Conceptualising Feedback Literacy: Knowing, Being, and Acting." *Innovations in Education and Teaching International* 49 (1): 31–40. doi:10.1080/14703297.2012.647781.

Tai, J., R. Ajjawi, D. Boud, P. Dawson, and E. Panadero. 2018. "Developing Evaluative Judgement: Enabling Students to Make Decisions about the Quality of Work." *Higher Education* 76 (3): 467–481. doi:10.1007/s10734-017-0220-3.

Tanner, K. D. 2012. "Promoting Student Metacognition." *CBE Life Sciences Education* 11 (2): 113–120. doi:10.1187/cbe.12-03-0033.

Torrance, H. 2012. "Formative Assessment at the Crossroads: Conformative, Deformative and Transformative." *Oxford Review of Education* 38 (3): 323–342. doi:10.1080/03054985.2012.689693.

Vygotsky, L. S. 1978. *Mind in Society; The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press. ISBN-10: 0674576292

Winstone, N. E., R. A. Nash, M. Parker, and J. Rowntree. 2017. "Supporting Learners' Agentic Engagement with Feedback: A Systematic Review and a Taxonomy of Recipience Processes." *Educational Psychologist* 52 (1): 17–37. doi:10.1080/00461520.2016.1207538.

Winstone, N., and D. Carless. 2019. *Designing Effective Feedback Processes in Higher Education: A Learning-Focused Approach*. Oxford: Routledge.

Yan, Z. 2020. "Self-Assessment in the Process of Self-Regulated Learning and Its Relationship with Academic Achievement." *Assessment & Evaluation in Higher Education* 45 (2): 224–238. doi:10.1080/02602938.2019.1629390.

Yan, Z., and G. T. L. Brown. 2017. "A Cyclical Self-Assessment Process: Towards a Model of How Students Engage in Self-Assessment." *Assessment & Evaluation in Higher Education* 42 (8): 1247–1262. doi:10.1080/02602938.2016.1260091.