TOWARD LOSSLESS LEARNING BY CONNECTING FACE-TO-FACE

ABSTRACT

A learning environment that is centered on a feedback loop between people risks lossiness when lost information compromises the quality of education. Online education has had an advantage over face-to-face (F2F) learning in that digital records log and preserve a great deal of education data. But online typically loses affordances commonly present in F2F. Blended education has been offered as a best-of-both-worlds option, but it does not solve the problems of lossiness in F2F environments. Because we expect F2F learning to persist, future technology can provide F2F instruction with capabilities native to online that facilitate increased participation and tracking. We describe attempts to decrease lossiness with connected F2F technology such as classroom response systems (CRS), and note an absence in technology solutions for tracking of more dynamic F2F learning activities such as those that require demonstration of process or performance.

THE CHALLENGE OF LOSSY EDUCATION

Education is often centered on a feedback loop of transmission, reception, and application for both instructors and students.

- Transmission (instructor): New information is imparted
- Reception (student): Information is perceived and captured
- Application (student): Information is interpreted and knowledge is constructed
- Transmission (student): Information is applied through performance
- Reception (instructor): Student performance is assessed
- Application (instructor): Assessment is interpreted to inform future instruction

Learning relies on the completeness and quality of information in this feedback loop; when information is lost, the quality of education is compromised. Learning is *lossy* when transmission, reception, or application of information is hindered or precluded.

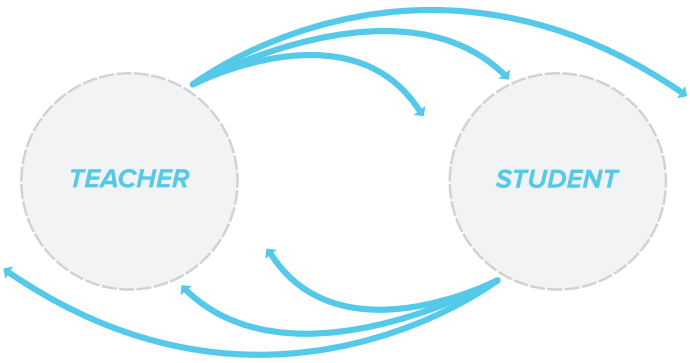


Figure 1. Education as a feedback loop between teacher and student.

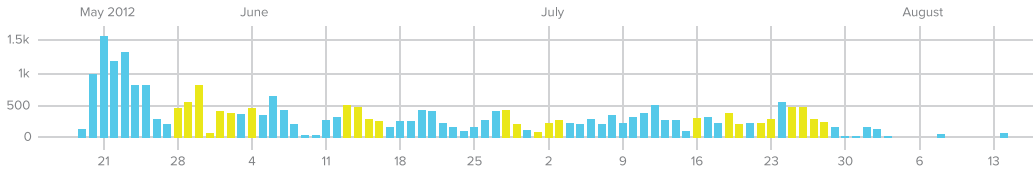
Figure 1 depicts *lossiness* within the feedback loop as some information hits the target while some does not. Part of the challenge of education is *making the invisible visible*,[1] whether that is transmitting information or assessing what was received and applied. Even when teacher transmission of information is complete, student reception may be lossy due to divided attention[2] or individual differences in background knowledge.[3] Students must also apply new information or it is effectively lost.

Continuing the feedback loop, assessments are designed to receive information on student learning, but such assessments can be lossy when they are inaccurate measures of ability, infrequent, incomplete, or misaligned with outcomes. Further, assessments are lossy when they do not provide formative feedback that is used to improve learning or instruction.

Traditional face-to-face (F2F) learning can be particularly lossy. Lecture, sometimes mocked as the "spray and pray" approach, emphasizes the one-way transmission of information. This makes it hard for students to capture all the information and for instructors to receive data to accurately assess student learning. Lecture can also implicitly encourage students' passive acceptance of concepts,[4] or worse, fail to change pre-existing misunderstandings by not directly challenging biases or interpretations.[5] It is no surprise that passive, one-way transmissions demonstrate increased failure rates of 55 percent over the more active forms of instruction.[6]

One of the stated advantages of F2F environments is that people can register expressions of understanding as a dynamic and informal means of assessment. But, are students signaling understanding[7] or simply compliance?[8] Cognitive biases and social misperceptions may prompt teachers to presume student understanding in the same way that people find patterns or draw conclusions where none exist.[9-11] Students can further teachers' misperception of understanding when they assume that others understand the materials and act as if they do.[8] This lossiness is compounded in large classes where it is not possible to assess each student's understanding, even at the most critical points. In sum, insufficient feedback on learning can simultaneously be transmitted by students and received by teachers, wasting valuable opportunities. While some loss is likely unavoidable, too much lossiness results in wasted time and missed learning objectives.

ACTIVITY
Each bar represents the number of page views on that day. A yellow bar indicates that some user took an action within the course on that day.



ACTIVITY
Each bar is an assignment. The blue layer represents the percentage of the students that turned in the assignment on time. Assignments that are late are yellow, and missing assignments are red.

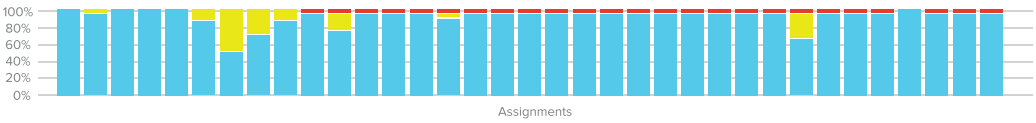


Figure 2. Canvas Analytics provides key data visualizations to both instructors and students to help them understand their online participation and behavior throughout the course.

DECREASING LOSSINESS WITH ONLINE TECHNOLOGY

Online education has provided capabilities that diminish lossiness by increasing opportunities to participate as well as tracking of both teaching and learning. The asynchronous nature of the Internet provides flexibility over time and space so all students can interact and be assessed, such as in online discussion forums. Digital media can capture instruction and be accessed by students when they are most attentive, at different speeds,[12] and reviewed as needed.

Additionally, technology can capture and make visible class members' online behavior and performance. The built-in analytics dashboard of a learning management system (LMS) may show student activity, including page views, course participation, and assessment metrics (Figure 2). This gives instructors and students new insights into students' time-on-task and aligns participation to learning outcomes. Analytics can also suggest how instructional design relates to overall class performance, leading to improvements in teaching. The real-time nature of analytics can prompt teachers to intervene and scaffold students in response to significant struggles.[13]

The breadth and depth of online data means that educators and researchers can gain further insights into student participation and performance by accessing data on their own (Figure 3). This unlocks a vast amount of data that can be tuned to specific channels that are relevant to particular subject matters or instructional methods. The availability of online data has increased demand for and interest in learning analytics and educational data mining as a means of constructing proxies for how people learn.

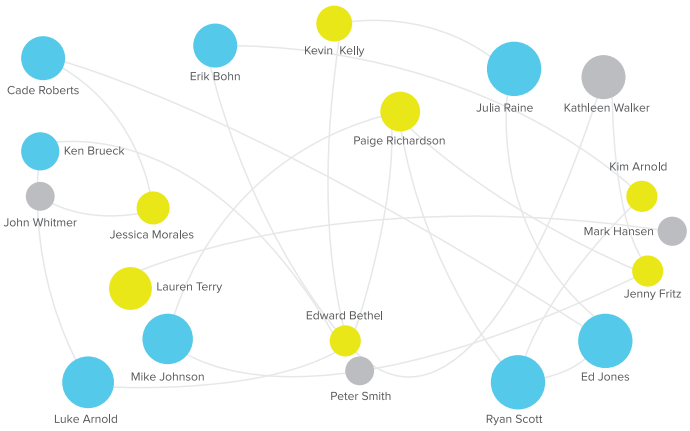


Figure 3. A social network analysis of Canvas Network online course discussions using open data.[14]

The caveat, of course, is that online data only documents behavior and performance conducted online, and usually within the confines of a learning management system. Even though online learning has been shown to achieve the same or better learning outcomes than traditional F2F learning,[16-18] and even though growth of online education in the U.S. has been steady (see Table 1), online education remains in the minority.[15] This is, in part, because many instructors reject the idea of online education based on a perception that it lacks the magic of F2F.[19]

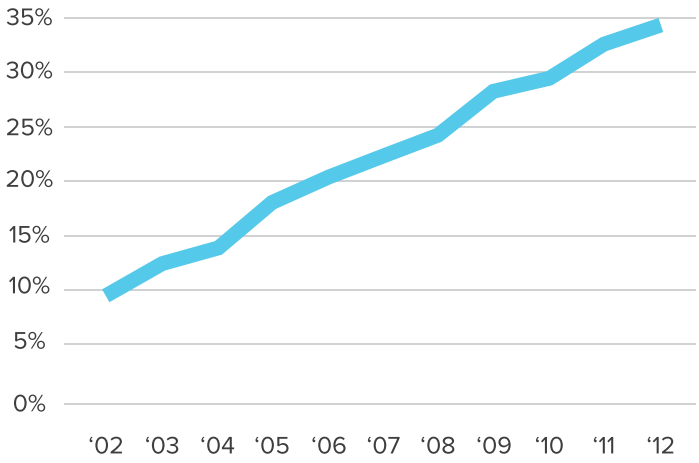


Table 1. Enrollments in online courses in the fall term over the past ten years. Adapted from Allen and Seaman.[15]

The following are key affordances of F2F learning environments that many teachers find lacking in online environments.[23]

- Synchronous: supports spontaneity and synergy
- Dynamic: provides cues for both verbal and nonverbal communication
- Sensorial: allows learners to engage all senses and interact with physical objects
- Social: creates bonds that can quickly form into a community

The lack of these affordances in online environments results in loss of information, and this lossiness can impede both cognitive and affective learning outcomes.[20, 21] While learning platforms like Canvas have provided more tools to increase humanness and interaction online without sacrificing flexibility,[22] F2F learning environments still maintain an advantage in these areas.

DECREASING LOSSINESS WITH ACTIVE LEARNING

The realization that online and F2F environments each have their own distinct strengths and weaknesses has led to blended learning models where course designers select the best of each mode.[24] Similarly, proponents of flipped classroom models shifted traditional face-to-face instruction (such as lecture) to the online environment as it is better suited for the digital world. By moving some activities into online spaces, blended and flipped models use available F2F time as an opportunity for active learning. Active learning can itself decrease lossiness by requiring participation in and demonstration of the learning process.

One way to engage students in active learning in a F2F environment is to simply provide students with *opportunities to respond*. Teachers ask students to respond to prompts orally, in writing, through gesture, or through performance as a whole class, small group, or individually. Opportunities to respond can decrease lossiness by getting more students to participate, but more importantly, by eliciting expressions of learning from the student that can then be used to tailor instruction. Deliberately designing instruction to provide these opportunities has shown increased student engagement with academic tasks,[25] decreased problem behavior,[26] and improved student achievement.[27]

Increasing participation and feedback, however, do not by themselves realize *lossless* learning. Indeed, increased participation increases information that needs to be received and applied by teachers. Teachers already find it difficult to manage F2F activities, log participation, and measure student performance. In the rare instances where logging participation does happen, instructors and students both recognize that the grade is subjective.[28] Perhaps this is why many instructors choose to use their records of F2F participation for little more than a fudge factor in the final grade where students are assumed to have participated if they attended.[29, 30]

Simultaneously providing consistent opportunities to participate in meaningful, active learning activities while managing and logging student participation is a challenge that connected F2F technology can potentially solve. The classroom response system (CRS) is one example of a tool used to facilitate whole-class participation with digital tracking. CRS technology relies on each student using a remote device to communicate responses to a teacher's central unit.

Instructional methods that take advantage of CRS's participation and tracking capabilities in the F2F classroom have been shown to increase engagement and improve learning outcomes specifically around conceptual understanding.[31, 32] One of the more compelling CRS-based instructional methods is peer instruction. In peer instruction, the teacher poses a question to the class; often it is multiple choice for the sake of time and objectivity. If results do not show that a majority of the class understands the topic, the teacher will direct students to work together to discuss, explain, and debate their interpretations before resubmitting answers. This gives teachers feedback on student understanding, which can be instantly logged and from which instruction can be tailored.

Peer instruction has been shown to increase student engagement, participation, motivation, and understanding, even in large classes.[33-36] The peer-to-peer interaction forces students to explain or defend their answers, and those that have misperceptions or misunderstandings are thus challenged—an important part of learning.[5] Peer instruction reinforces

THE PEER INSTRUCTION METHOD

Last week, Professor U. assigned some readings to the class regarding momentum. This week, the principles of momentum are being demonstrated and a question is posed to the students via a classroom response system: "Imagine that a ping-pong ball and a bowling ball are moving toward you. Both have the same momentum. If you exert the same force to stop each, how do the time intervals to stop them compare?" (1) It takes equal time to stop each. (2) It takes more time to stop the ping-pong ball. (3) It takes more time to stop the bowling ball.

Some students cast a vote right away, while others take time to carefully consider the question. After all have voted, Professor U. sees an almost even split between two of the answers. The goal in peer Instruction is to have at least 80 percent of the class select the correct answer. Before conducting the poll again, Professor U. prompts students to form small groups, discuss the question, and come to a consensus about the correct answer.

Professor U. observes the discussions and joins one group that remains confused by the question. After asking the professor to "explain that one more time," the group achieves its "aha" moment. When students recast their votes, the 80 percent correct threshold is met, and Professor U. proceeds to the next topic.

corect understanding, or adds detail when collaborative explanations fill in knowledge gaps. Also, peer instruction can facilitate a serial exhaustive search[37] of students' own knowledge before looking to the expert for an easy answer.

Despite the effectiveness of peer instruction and related CRS-based methods, fewer than 9 percent of instructors use CRS technology.[38] This may be because today's CRS technology is perceived as a novelty to some teachers and burdensome to others. The CRS is ancillary to an LMS, a core technology suite for many teachers. Many CRSs still require additional hardware, adding extra cost to students. In order for instructional models like peer instruction to gain traction among regular faculty, CRS technology must improve ease of use and diminish barriers to adoption.

Additionally, the CRS shows potential as a connected F2F technology for decreasing lossiness in learning by targeting conceptual understanding. Yet some learning outcomes require greater instructional flexibility and spontaneity. For example, while engineering courses may benefit from assessing conceptual understanding in the lecture hall, application of that understanding may be best assessed when directly observed in the lab—a situation that CRS would struggle to facilitate or improve.[39] Other examples from across disciplines include: second language learning, where students communicate orally with teacher and peers;[40] sciences, where students work in labs to perform steps in an experiment; communication, law, or business classes, where students debate or present cases; the arts, where students perform music, act, or produce other artistic expressions; and physical education, where students perform physically and engage in a number of team building skills.[41]

Teachers attempting to accurately assess ability, attitude, or even understanding in less formal F2F environments must overcome more pervasive lossiness. This is due to the need for logging individual and group performance quickly, aligning learning outcomes with a framework for assessments, and maneuvering between assessing outcomes and observing students who are dynamically exhibiting knowledge, skill, or attitude. These demands are complicated by the fact that instructors use multiple instructional methods and need to be fully engaged with one or more students at a time.

Can we envision a single, connected F2F technology that would allow teachers flexibility to work with the myriad dynamic, sometimes informal instructional methods while reducing lossiness? To satisfy the demands of in-class usage on a variety of directly observed student performances, a connect F2F technology for dynamic learning would do the following:

- Facilitate participation for individual students and the whole class
- Encourage direct observation of student demonstration or performance
- Make it easier for teachers to log student progress toward outcomes
- Integrate seamlessly into existing teaching and learning practices
- Accumulate data within central school systems for reporting

Contemporary technology suggests a lightweight, Internet-based mobile tool could allow teachers to quickly log students' individual and group performance on a task. If those tasks simply reflected established competencies, standards, or learning outcomes, accumulated student data could be readily compared with others within the class, throughout an institution, or across geographical regions. Simplicity of features and design would be important in allowing teachers to practice a wide variety of learning activity types without encumbering them with too many steps or options.

CONCLUSION

The first 20 years of online education have resulted in a number of technologies and tools that diminish lossiness in teaching and learning. Modern learning platform providers have most recently focused on enhanced multimedia and convenient access to participation and assessment data for both teachers and students as a means of further decreasing the loss of relevant learning information.[42,43] Still, F2F remains a compelling mode of teaching and learning for numerous reasons, not least of which are the positive affordances such as humanness that are still hard to replicate online.

To spur innovation that progresses education toward lossless learning across learning environments, specifically in F2F, educators need new tools that assist their current repertoire of active learning methods. CRS has proven effective for decreasing lossiness when learning outcomes center on conceptual understanding (using active learning methods like peer instruction). But less formal instructional methods will remain lossy in the absence of a reliable participation tracker that does not force instructors to sacrifice their ability to be in the moment with their students.

"What teachers do matters," writes John Hattie.[44] If we want to decrease lossiness and realize the potential of technology while preserving what is best about both F2F and online, this means having new technology is not enough. Educators must begin to think about their role as facilitators of active learning, and then design, iterate, and do new things with F2F experiences that are both participatory and connected.

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