How may the use of student computing devices speed up the cycle of formative assessment and differentiated instruction? School administrators Richard Kassissieh and Jeff Tillinghast describe the intersection of BYOD and education theory at University Prep, a grade 6-12 independent school in northeast Seattle.

In the past three years, University Prep has made wholesale changes to how technology supports instruction in the school curricula. The most visible of these changes has been the introduction of a 1:1 student device program, in which all students bring personal computing devices to school each day and use them in a variety of ways to support their studies. When designing this program, we had the benefit of learning from the experiences of schools that have been running student laptop programs for up to 14 years. Introducing devices would be only one piece of the change in our educational ecosystem, and arguably not the most important one. A clear theory of action for how device capabilities amplify and extend good education practice would be the most important quality of U Prep’s technology initiative.

In brief, our theory of action includes 1) clear and frequent expression of the reasons for the initiative, 2) learning environment design grounded in education research, 3) horizontal and vertical alignment of school support for the change, 4) professional development linked to individual teacher improvement goals, and 5) design for student responsibility and leadership. A full explanation of these ideas exceeds the scope of this article, so we focus our discussion on one key aspect of the model: the strategic use of technology tools to enrich the cycle of formative assessment and differentiated instruction. Our teachers, in consultation with the authors, have adopted and continually develop and refine methods to provide students with timely feedback on their subject mastery and then direct them to further instruction in the areas where they need it most.

High quality formative assessment is timely, actionable, and specific (Black & Wiliam, 1998; Stiggins, 1997). The assessment occurs after students have engaged with learning activities for the topic, but before they move on to another topic, thus it is timely. Feedback focuses on observable qualities of the student work, not immutable characteristics of the student, and thus it is actionable. The assessment focuses on discrete learning objectives, whether concrete or abstract, and thus it is specific. Effective formative assessment therefore provides feedback to the student while the subject is memorable, focuses on what the student did, and specifies a small enough component of the overall work that the student can handle.

Timely, actionable, and specific feedback invites a response from the student, the ideal moment for a teacher to differentiate instruction and provide the specific next steps for that student to
improve mastery in identified areas. The variation of learning activities for individual students needs is one form of differentiation (Tomlinson, 1999). However, even the most skilled teacher cannot always provide an effective response to each student’s learning needs on the spot. The effective teacher prepares in advance a diverse collection of learning activities designed to redress the typical obstacles encountered by students and is therefore ready to direct each student to the appropriate activity based on the results of his or her formative assessment. Ideally, students are not only repeating prior learning activities but also approaching the material in different ways that will allow them to learn what they did not master the first time through.

To a certain extent, formative assessment and differentiated instruction are both information problems. Teachers build and then distribute formative assessment instruments to students, collect the results, individually summarize the implications, and then direct each student to the subsequent, matching learning activity. It is therefore not surprising that technology tools have dramatically improved our ability to practice effective formative assessment and differentiated instruction. One teacher would find it next to impossible to individualize all of the information collection, analysis, and distribution required by a class of 20 (or 40) students. This may be why whole group instruction has been the dominant classroom methodology for decades, and effective formative assessment and differentiation has been less common. We have found information technologies very effective at speeding up the cycle of study → formative assessment → individualized study → summative assessment. If a teacher expects to cover a number of units in each term, then efficiency and speed in these processes is necessary.

We classify the technology tools we use for formative assessment and differentiated instruction into two categories: general-purpose and subject-specific. General purpose tools such as Google Docs (or another collaborative document editor) and Schoology (or another learning management system) are designed to facilitate non-specific information flow. However, our teachers use these general-purpose apps in very specific ways. Subject-specific apps such as DuoLingo and DragonBox are very precise in their area of focus, providing feedback and practice for a discrete set of topics in languages and math.

**General Purpose Apps**

Common web-based tools can be applied in ways that match varied subjects, age levels and pedagogical techniques. Teachers take these tools, generalized in function, and use them in a variety of ways to support specific teaching objectives. Some examples of general purpose apps follow:

**Live progress reports.** Our sixth grade students, all new to the school, matriculate from 45 different public and private elementary schools. Thus, students’ prior preparation varies considerably both in terms of content and emphasis. However, our school does not track students based on documented problems associated with this tracking (Werblow, Urick, & Duesbery, 2013). Differentiated instruction is therefore an essential strategy to ensure that all students in heterogeneous groupings are appropriately challenged. Technology tools allow the teacher to accurately track formative assessment results and share them with students, so that appropriate instruction is provided for each individual.

Our sixth grade math teacher shares a Standards and Assignment Log with each student at the start of the year. Google Docs sharing settings allow the teacher to update the document after each assessment, and the student is then able to access the latest summary at any time. The document includes all of the learning objectives, with blank columns for assessment results, along with optional comments. Feedback is individualized for each student in a separate document. For each topic, the teacher first records formative assessment results, then directs the student to the appropriate leveled practice problems. After the student completes these differentiated exercises, then the teacher takes the summative assessment, and the teacher updates the student’s level of mastery as needed. Using this document, the student can see what topics in the course he or she has mastered and which require more study. Figure 1 and 2 show sample digital documents used for organizing Standards and Assignment progress reporting.

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**Quarter 2: Standards and Assignment Log**

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Evidence of Mastery</th>
<th>Evaluation</th>
<th>Comments and Interventions</th>
<th>Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to find the prime factorization of a number.</td>
<td>Proficiency Evaluation: 1/1</td>
<td>10/10</td>
<td>Level 3 Practice: complete</td>
<td>Level 4 Practice: incomplete</td>
</tr>
<tr>
<td>Students will be able to find the greatest common factor of two numbers using prime factors.</td>
<td>Proficiency Evaluation: 2/2</td>
<td>9/10</td>
<td>End of Unit Check: 100%</td>
<td>Level 3 Practice: complete</td>
</tr>
<tr>
<td>Students will be able to reduce fractions using the GCF.</td>
<td>Proficiency Evaluation: 2/2</td>
<td>8/10</td>
<td>End of Unit Check: 100%</td>
<td>Level 4 Practice: complete</td>
</tr>
<tr>
<td>Students will be able to find the least common multiple of two numbers using prime factors.</td>
<td>Proficiency Evaluation: 2/2</td>
<td>9/10</td>
<td>End of Unit Check: 100%</td>
<td>Level 3 Practice: complete</td>
</tr>
</tbody>
</table>

**Figure 1.** Individualized progress report for sixth grade math.

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**Figure 2.** Leveled practice sets for closing gaps in knowledge and skill.
Performance feedback. The use of a web-based discussion thread, forum, or assignment dropbox offers opportunity for individual and group dialogue that moves beyond constraints of class meeting time or course size. Many classes use these tools as discussion vehicles for students to collaborate on homework or ask questions of each other outside of class. A music teacher uses it as a vehicle for individuals to submit examples of their performance and get individual feedback that is normally difficult to accomplish in a large ensemble setting. This allows for increased differentiation by support as the teacher can clearly identify which members of the ensemble are successfully performing the piece and which require additional instruction. In seventh grade English, students submit written assignments electronically to a digital dropbox. Both teacher and students retain access to all drafts and comments, and class time is not used for the distribution and collection of paper. In math classes, students create their own explanation videos and receive feedback on the quality of their presentations. Figure 3, 4, 5, and 6 show use of a digital dropbox for feedback, markup, record keeping, and student-crafted instructional videos.

Portfolio assessment. Use of web-based courseware such as a learning management systems or file-management cloud applications such as Google Drive or Dropbox allow teachers and students to collect electronic work in a central location which can be easily accessed for review and reflection at a later date. Reflective activities can ask students to review past work and comment upon it or revise it. In our middle school, students prepare student-led conferences where they present examples of their best work over the academic quarter to their families. Being able to access conference material several weeks after initial use gives students a wide range of work from which to choose. In addition, use of publishing platforms such as blogs provide students opportunities to select best work and present to a wider audience. In one of our courses, Advanced Topics in Math, students write about their independently-designed research projects on WordPress blogs and receive feedback from observers. Figure 7 shows an example WordPress blog post with student project.
Subject-Specific Apps

Self-contained study and practice environments allow students to observe, think, try, receive feedback, and then study further. This “adaptive learning” method is designed to allow students to progress through material independently of a teacher. Critically, the feedback is immediate, as the computerized system evaluates the student response and indicates level of mastery right away. Assessment is typically atomized by topic, so that feedback suggests which topics students have mastered and which require further practice.

Equally important, these digital learning systems incorporate some aspects of differentiation. In mathematics systems such as Khan Academy, IXL, and DragonBox, the software requires students to demonstrate mastery of the current activity before proceeding to the next. As a form of pace differentiation, a student who needs more practice gets it, while the student who is ready to proceed moves on. Additionally, such systems typically moderate question difficulty based on student success, so that a student who answers the current question correctly gets a harder question next, whereas the student who answers the current question wrong sees a less challenging question next. The idea is that this keeps the student working at an appropriate level of challenge over a sequence of many questions.

New digital learning systems usually provide an individual dashboard for students to monitor their progress, and some provide a teacher dashboard to monitor the progress of all students. This is critical for the communication aspect of good teaching - both students and teachers know how much work has been completed, as well as where they have demonstrated understanding and where more practice, review, or elaboration is needed. Figures 8, 9, and 10 show examples of adaptive mathematics and literacy applications.

Such adaptive learning systems emphasize pace-based differentiation, rather than differentiation by instructional method or student interest. A student who needs more practice is encouraged to repeat more activities of the same kind, rather than approaching the material from a different perspective. Students using Khan Academy may re-watch the same whiteboard-based instructional videos or attempt more quiz questions of the same type. DragonBox provides “hints,” revealing an animation of the solution for students to watch before they re-attempt the same problem as before.

However, it may be noted that subject-specific apps rarely differentiate by modality, so students lack the opportunity to approach the material using a different set of thinking skills. As a result, our teachers do not feel that automated instructional systems can replace teachers in the educational process. Digital learning systems are useful but ultimately incomplete when meeting the diverse and complex learning goals of our students. Digital learning apps provide one more instructional tool to diversify a teacher’s skill set, along with face-to-face instruction, group work, paper-based exercises, physical manipulatives, and so on. We believe this hybrid approach has led to significant improvements in pedagogy at University Prep.

**Project-based learning.** Examination of apps like DragonBox may suggest neglect of constructivist learning theory, but this is not the case. At University Prep, teachers who practice project-based learning find technology very helpful. Project-based learning is inherently differentiated, as individual students or groups generate project questions, locate and analyze the necessary resources, and produce work that demonstrates new knowledge and skill. Since different students are working on different topics at their own pace, and the teacher may not have ready access to all of the required support materials, technology is an essential tool when working on projects. Students may independently search for relevant content, record and analyze data, share work with their partners, and communicate with experts in the field. The growing interest in engineering and design have created new opportunities for students to use technology to create prototypes, model systems, and conduct physical experiments as part of the inquiry process.

Use of formative assessment for the collection and management of feedback is not limited to those technologies or approaches already discussed. The ability to place one data point or performance in context of a student’s growth informs both teachers and students. Good teachers understand how one performance fits within a larger trend of overall mastery or areas of challenge. Likewise, use of portfolios, reflective writing, and self-assessment shows how educators everywhere have taken an interest in having students think metacognitively. Metacognition means thinking about one’s own thinking and it is manifest when learners identify strengths and weaknesses, and resources for getting help to close performance gaps. Instructional technology can aid this process by providing an easy way for teachers and students to archive materials over time (including over an entire school year or longer). Figure 11 shows a sample index of student performance evidence.
This data collection over time allows students and teachers to make informed decisions about the next relevant and meaningful instructional steps in a student’s learning. Providing methods for students to demonstrate their achievement relies on having enough evidence to make accurate evaluations of differentiated processes and products.

Conclusion

Technology tools enhance the cycle of formative assessment and differentiated instruction at University Prep. Ubiquitous computing systems allow teachers and students to experiment with a variety of apps and techniques to assess mastery, provide feedback, and suggest appropriate subsequent activities. These techniques fall into two broad categories: general-purpose and subject specific. General-purpose tools provide sufficient flexibility for teachers to use them for formative assessment and differentiated instruction across a wide range of topics and teaching strategies. Subject-specific tools have formative assessment and differentiated instruction strategies built into them but typically only require a narrow range of approaches. Thus, subject-specific tools are most useful as an addition to the teacher toolkit, to provide greater differentiation in instruction, when incorporated into a diverse learning environment.

The landscape of digital tools for education is constantly evolving. The apps described in this article are substantially different than they were even just a year ago. What further enhancements might we see in the coming years, and which would be most helpful for learning? In the case of general-purpose tools, recent improvements have largely focused on usability and mobility. These systems have become progressively easier to use, so that less time is spent instructing teachers and students how to use them, and more time spent deploying them. The systems have also become more mobile, as cloud storage has removed the need for file management and made course content, student work, and teacher feedback available at all hours, from school and at home, and on any variety of handheld devices. Subject-specific tools now provide a greater variety of learning modalities and adaptations, allowing students to study and receive feedback independently of the teacher. However, the content of these systems remains somewhat static.

An ideal next step for education would be to blend the flexibility of general-purpose tools with the adaptive qualities of subject-specific tools. Surely, most educators would appreciate an adaptive testing system which permits entirely customizable content and learning pathways, like a combination of the best qualities of Khan Academy and CK-12. At University Prep, we will continue to look with interest upon the education technology landscape for opportunities to use more powerful and flexible techniques to enhance teaching and learning.

Summary of University Prep’s Approach to Digital Learning

One-to-one iPad use for middle school students
One-to-one laptop + tablet in upper grades
Schoology learning management system
Notability and OneNote for stylus input
Google Apps for Education
AirPlay-equipped projectors in classrooms

References


