A Systematic Review of Technologies for Providing Feedback and Grades to Students

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Introduction

It can be a daunting task to identify, compare, and select a tool to assist with the task of providing feedback and grades to students. There are multiple tools available that have varying capabilities and cost. Some feedback tools are provided within learning management systems (LMS) (e.g. Blackboard, Moodle) while others are standalone implementations, such as feedback software (e.g. GradeScope, Crowdmark), third-party plagiarism checkers (e.g. TurnItIn, Viper), and highly specialized tools such as those for automatically grading coding assignments. While each of these tools has the potential to reduce the time spent by instructors, providing effective, timely feedback to students should still be the focus.

This paper reviews commercially available products that can assist or automatically grade assignments and provide feedback to students. First, each tool is categorized based on features. The categories include plagiarism checking, assignment feedback and rubrics, and annotating writing assignments. These categories are selected based on their broad applicability to higher education STEM instructors. Then the tools in each category are summarized based on publicly available data and free trials. The goal of this study is not to necessarily recommend one tool, but to bring important information into one place to make it easier for instructors to compare and select the tool that will work for them, their students, and their course.

Background

Assessment and feedback are important parts of the learning process. However, providing individualized feedback to students can be very time consuming for faculty and teaching assistants. Therefore it is important to provide authentic assessments and feedback that support learning [1] while balancing the time required by course staff. New computer-based tools have been developed to assist instructors with grading and feedback beyond the traditional multiple-choice Scantron based test.

Learning management systems (LMS) or course management systems are the most popular tools for use in higher education. There have been numerous papers in the literature about using features of various LMS platforms in STEM higher-education courses over the last two decades [2-24]. Some examples add to traditional on-campus experiences while others share their use in online courses or MOOCs [14, 25].

Additionally, computer-based products that are more discipline-specific have also been created. For example, electronic textbooks or e-textbooks now include interactive lessons and examples that are autograded [26-29]. More and more, traditional textbook companies are moving their homework problems to online question banks. There are also websites and software packages to evaluate work for a specific discipline such as code [30-33] or sketching and CAD [34-39]. The discipline-specific tools have been developed both commercially and by instructors.

One group of tools that is not widely discussed in the literature includes commercially available tools that provide broadly applicable features to supplement a traditional LMS platform. These tools can include additional forms of feedback or the ability to provide electronic feedback for assignments turned in on paper. This paper focuses on electronic tools in this category that may be useful to higher education STEM instructors.

Purpose and Scope

The purpose of this paper is to categorize and compare electronic tools to assist with providing feedback and grading of assignments in STEM higher education. It can be a daunting tasking to find one that will work in a specific class. This paper focuses on electronic tools for assisting in grading that are outside the typical LMS. Generally, individual instructors are limited to the LMS selected by their university. Additionally, the university IT department and/or teaching and learning center provides additional support for instructors who are using the selected LMS. In a 2017 survey that I conducted [40], almost 70% of the respondents indicated that they use the LMS that was available from their university. Additionally, there is existing research about the use of standard LMS features in courses. So, this paper focuses on tools that can be added to or used in addition to an LMS, especially if the features of the LMS are limiting the types of assignments or feedback.

Methods

To identify tools for this paper, I referenced the literature, university teaching and learning centers, educational organizations, teaching blogs, and internet searches. Search terms included "automatic grading," "electronic grading," "electronic rubric," and "electronic assessment." Based on the results of these searches, tools were evaluated to determine whether to keep for further analysis or discard from consideration. Tools were discarded if they were developed primarily for K-12, an LMS, outdated (more than 5 years since the last update), or did not include features to provide feedback to students on assignments. The remaining tools were separated into these categories: online grading and feedback, writing, and plagiarism checking. Then the features of each tool were summarized. All data used in this paper was obtained via the tools' websites, publicly available information, or free trials. If a tool provides individual licenses and pricing options were publicly available, that information was included in this paper. If a tool provides department or campus-wide pricing, that information is generally not publicly available due to the customized quoting process used by most software companies.

Results

The tools within the scope of this research were placed into the following categories: online grading and feedback, writing, and plagiarism checking. There were eight tools identified. The features of each of the tools are summarized below.

Online grading and feedback

This category includes tools that include a variety of features to provide detailed feedback and grades to students for an assortment of assignment types and formats. Each of the tools in this category can be used outside of an LMS, however, an LMS plug-in may also be available. The three tools in this category include GradeScope, Crowdmark, and iRubric.

GradeScope

GradeScope provides tools to grade written, digital, and coding assignments with rubrics and AI-assisted grading [41]. The rubrics are flexible, detailed, and editable during grading [41]. If rubric changes are made, they are applied to previously graded work [41], see Figure 1. The AI-assisted grading feature groups similar answers together so that similar answers can all be graded at once [41]. GradeScope also provides assignment statistics at the assignment, question, and rubric item levels. Paper-based assignments can be uploaded by the instructor or student. Grades and feedback can be sent to each student via email [41]. Students can review their feedback, download a graded assignment, and request a regrade from the GradeScope website [41]. Grades can be exported from GradeScope and into an LMS or another grade book [41]. GradeScope also includes LMS integration options with a university-level license [42]. GradeScope also offers licenses to individual instructors or teams of instructors at a per-student cost of $1 to $5, depending on the number of instructors and features [42]. GradeScope also offers campus-wide pricing [42]

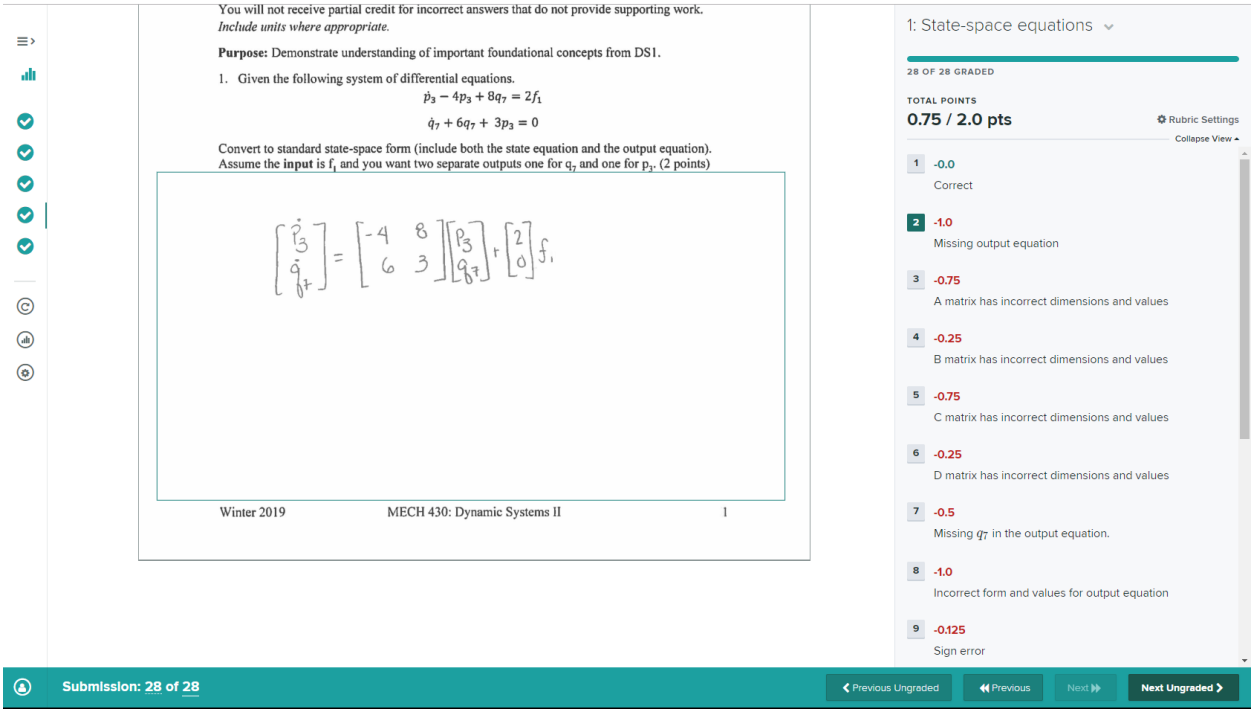

Figure 1 - Grading interface on GradeScope

Crowdmark

Crowdmark provides tools to grade paper-based assignments with flexible tools, annotations, and automatic score calculations through their web interface. There is also an ability to easily reuse comments between students. Assignments can be graded collaboratively, and analytics are provided for each assignment and question. Crowdmark also includes LMS integration. Grades are returned to the students online. Since Crowdmark only provides department- and university-wide licenses, pricing for the tool was not available on their website [43].

iRubric

One of the products created by RCampus is iRubric, a tool to create rubrics, assesses assignments, and share results. It is free for individual instructors and students. Instructors can start a rubric from scratch or from one of over 500,000 publicly available rubrics. Once a rubric is created and saved it is immediately added to the public database unless the user specifies that it should be held for 14 days [44].

The rubric format in iRubric is a traditional grid rubric with levels of performance as columns of the grid and criteria as the rows, see Figure 2. The rubrics can be used directly from the website or they can be printed. RCampus also provides a gradebook and other features similar to an LMS. Rubrics can be created with a free account; however, RCampus requires their gradebook product to assess student work electronically using iRubric. Individual licenses for RCampus' Gradebook Plus Unlimited are $4.95 per month [45].

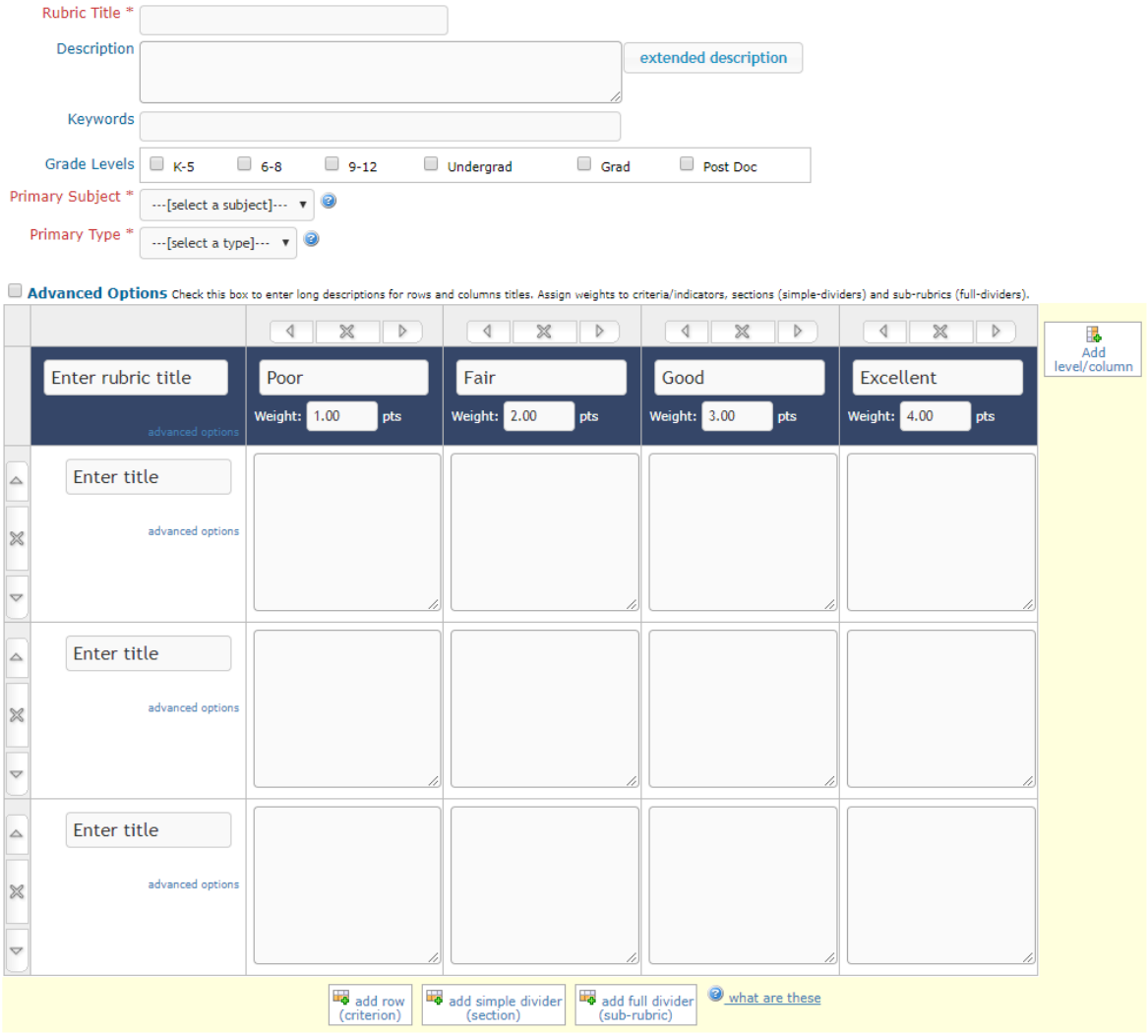

Figure 2 - Basic template for building a rubric from scratch using the Rubric Studio from iRubric

Writing

In addition to creating annotations using software such as Microsoft Word or Adobe Acrobat, there are three additional tools for marking and annotating written assignments: iAnnotate, SAgrader, and Kaizena. The annotation features provided by these tools go beyond the annotation and feedback tools available in some LMS platforms.

iAnnotate

iAnnotate is an app to read, annotate, and share various documents with an iPhone or iPad. It supports Adobe Acrobat files, Microsoft Word, Excel, and PowerPoint files, image files, and websites. Documents can be accessed from various clouds such as iCloud, Dropbox, and Box [46]. The fourth version costs $9.99 in the Apple App Store [47]. The app is not available for any other platform or via a web interface.

SAgrader

SAgrader is designed to give content-specific feedback for short answer prompts and essays automatically. There are currently assignments to reuse or you can build your own. It provides personalized, content-focused feedback immediately to students. The features to evaluate grammar and spelling are still in development. It uses natural language processing to evaluate the submitted work, which is different than other essay grading software that is based on human-graded models. The cost starts at $5 per student [48].

Kaizena

Kaizena is a tool specifically designed to provide feedback to assignments in Google Docs. It has support for automatically created and custom rubrics. Additionally, instead of typing comments, Kaizena allows instructors to record voice messages with feedback or embed YouTube video lessons [49].

Plagiarism checking

While some LMS platforms include plagiarism checking features (e.g. SafeAssign is a feature of Blackboard), there are numerous additional plagiarism checking websites that also offer additional features. Some plagiarism checking software is marketed to students to use before turning in their papers and others are marketed to faculty to check for plagiarism after students hand in their assignments. Both TurnItIn [50, 51] and Viper [52] provide the ability to check student essays against a database of existing content. They differ in their privacy policies and payment plans. Viper is a pay-as-you-go platform where the author retains ownership of their work and receives a free limited report [52]. TurnItIn includes a product called iThenticate, a basic plagiarism checker [51], and also Feedback Studio, which includes a rubric and feedback platform for writing similar to some of the features in the previous annotation category [50]. TurnItIn products also include the ability to integrate with existing LMS platforms [50]. The pricing for TurnItIn products is not publicly available.

Discussion

In general, these tools each provide the instructor with a feature that is not readily available in many LMS platforms. This may be because the feature is not broadly applicable to all LMS users or because a group of instructors decided to create a new tool that would be helpful to them.

As with all forms of educational technologies, instructors should evaluate the tool before adopting it for a course. When using a tool for grading and feedback, instructors would be wise to understand how laws such as FERPA, other government regulations, and institutional policies govern what may be done with student work. A review of privacy policies for each tool should be conducted. Proper review of these policies may necessitate consultation with other university departments such as information technology or legal services. Grading and feedback tool vendors are generally aware of the need to comply with FERPA and make the information easy to find on their website and in their privacy policies.

There are also more pragmatic concerns, such as the learning curve for the instructor and graders as well as the students' ability to use and learn from the feedback provided in the tool. Before I decided to use the free trial of GradeScope on a complex and lengthy exam, I tried grading a simpler quiz first. This allowed me to get used to the assignment workflow and test out the system on a straightforward, lower-stakes assignment. If I had run into problems, it would have not been difficult to regrade the quiz by hand. However, I found using GradeScope to be easy and efficient, so I continued using it.

If a student preview mode is not available in a particular tool, I will often add myself as a sample student using another email address. The additional account allows me to see exactly what the students see and demonstration the tool in class if necessary.

Online grading and feedback

Both GradeScope and Crowdmark offer very similar features for feedback and grading of paper-based assignments that go beyond traditional features in an LMS; see Table 1 for a comparison of the features of both tools. Since these tools are paper-based, a wider-variety of questions can be asked, allowing any answer which a student may place on the paper (e.g. design problems, sketches, mathematical derivations, annotated figures). Additionally, students can more easily show the work they used to find the solution on a paper-based assignment. The grading process generally requires the instructor to review each student response, however, features such as keyboard shortcuts, reusable comments, and AI-assisted groups can speed up the process.

After using the free trial of GradeScope for two terms, I have found that I have been able to decrease grading time, reduce errors, improve my feedback to students, and understand what mistakes commonly occur on assignments. It is an improvement over grading exams on paper as I had done prior to using GradeScope. Having used both GradeScope and Blackboard to grade similar assignments, I find both platforms offer conveniences, such as less paper to carry around, grading from anywhere, electronic returning of assignments, and data analytics. Some advantages of GradeScope include more flexible rubrics, the ability for students to show their work including sketches and equations, and keyboard shortcuts. For STEM courses, GradeScope adds the flexibility to electronically grade paper assignments, handwritten derivations, and sketches. Additionally, the questions are not limited by the types of questions available in an LMS. Blackboard's advantages include automatically graded questions and that assignments and grades are included with the rest of the course materials. There is not a free trial available for Crowdmark, so I have not been able to test it directly. However, the videos and help information available on the website seem to indicate Crowdmark offers the same advantages for grading paper assignments, derivations, and sketches as GradeScope.

Table 1 - Comparison of GradeScope and Crowdmark

Feature	GradeScope	Crowdmark**
Interface	Website	Website
Collaborative grading	Yes, multiple instructors or teaching assistants can grade the same assignments*	Yes, multiple instructors or teaching assistants can grade the same assignments
Progress tracking	Yes, including who graded each question	Yes, including who graded each question
Individual feedback on submitted work	Annotations with mouse or stylus, text annotations*, highlighted boxes	Annotations with mouse or stylus, text comments with hyperlinks, images, mathematical or chemical notations
Grading options	Positive or negative scoring rubrics with keyboard shortcuts, rubrics can include mathematical notations	Rubrics are comments with points. Instructors drag and drop rubric items onto the student's work to apply the points.
Data and analytics	Data and analytics provided by question, assignment, rubric items, and key words	Data and analytics provided by question and assignment
Assignment submissions	*Instructor:* scan and upload paper assignments for each student *Student:* image upload for each question or one pdf for the assignment *Online assignments:** currently being developed with limited question types *Additional options:** autograded programming and bubble sheets	*Administered:* create a template, upload to Crowdmark for additional formatting and adding a QR code, then instructor or assistant scans and uploads completed assignments. *Assigned:* image or pdf upload for each question
Automated grouping	Groups images of similar answers together to allow for grading as a group of answers*	Not available
Returning grades	Instructor reviews grades, then selects the option to release the grades to students and if the students should be notified via email	Instructor reviews grades, then selects the option to release the grades and then students will be notified via email
Grade export	Yes, CSV or Excel	Yes, CSV format
LMS integration	Available*	Available

* additional cost above basic solo instructor account
** pricing information not publicly available

iRubric is different from GradeScope and CrowdMark in that it only provides an interface to create and print rubrics. Assessing student work electronically requires additional paid features that are redundant to most LMS software. The rubrics created in iRubric are traditional grid-based rubrics like the ones provided in most LMS platforms.

The only advantage of iRubric is the public database of example rubrics that are created by other instructors. The database of examples is searchable by discipline (e.g. chemistry, engineering, physics), type (e.g. assignment, portfolio, writing, exam), and level (e.g. undergraduate, graduate, post-graduate). For engineering educators, it is hard to find good engineering examples as they are all lumped into the same category. Therefore, it does not seem that iRubric provides significant additional rubric features that are not currently found in other LMS tools.

Writing and plagiarism checking

Written assignments commonly require instructor feedback with annotations. Apps (e.g. iAnnotate), software (e.g. Microsoft Word, Adobe Acrobat), and some LMS platforms (e.g. Blackboard) provide electronic versions of comments to replace paper-based comments, save instructors the effort of carrying around stacks of paper, and allow assignments to be returned electronically. Electronic annotations also provide a backup if paper copies are lost. Plagiarism checking websites and LMS features allow instructors to easily and broadly check for instances of plagiarism, however, the results need to be taken in the context of the assignment and the expected similarities between students. In this category, it is difficult to determine the differences between these tools and the features provided in each LMS platform based on publicly available information.

The use of commercial plagiarism checkers has been widely debated, due to how student work is used after it is scanned by the checking software. On one side, a plagiarism checker is only as good as the database it scans against. Since common forms of plagiarism include reference material and other student work, it is necessary both types of sources are represented in the database that new work is scanned against. When a student uploads an assignment for checking, that assignment is often added to the database for that software for use in future plagiarism scans. This leads to the other side of the debate, as students lose control of their intellectual property and it is used by the company to earn a profit [53, 54]. When a student uses a site to check their work it may also be used beyond the plagiarism checking database. For example, Viper states that it will use student essays as an example on another one of their websites three months after they are scanned [55]. Before using a plagiarism checker that might use student work for purposes beyond the immediate plagiarism scan, students, instructors, and institutions should consider the advantages and disadvantages of using such software.

Conclusions

Many instructors are using features available in LMS platforms to provide feedback and grades to students. However, there are limitations to the types of assignments and feedback that can be provided within most LMS platforms. There are useful alternatives to supplement the available LMS platforms, which extend or compliment the LMS features and allow the instructor to provide their desired feedback. This paper summarizes the features of eight additional tools that can be used to expand feedback and assignments in engineering courses.

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