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Development of a tool to support continuous assessments and improve the feedback cycle on statistical analysis assignments for large classes

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The purpose of this paper is to describe the development of a tool, AGStex (Assignment Generation Software using Latex), that enables educators to generate individual assignments tasks and to provide targeted feedback to students in large classes in a timely manner. In this paper, the initial development of the tool targeted at a statistical data analysis course in the field of biomedical engineering is presented. In addition, the authors illustrate how educators can utilise the feedback generated by the tool to improve student learning in large classes. The paper concludes with an outline of the next steps for the project including suggestions on further work needed to inform the impact on the types feedback generated by AGStex on students' learning outcome.

Keywords: computer-based assessment, feedback, large class, higher education

Introduction

The primary focus of assessment and feedback is to help students reduce the gap between current understanding or performance and a desired goal (Hattie & Timperley, 2007). Despite its importance, particularly for large classes, academics are constantly struggling to provide sufficient opportunities for students to apply their understanding of the concepts learned after face-to-face lessons. Coupled with limited resources, the provision of quality feedback on practice exercises and assignments tends to be compromised. The situations were especially grave for assignments that require open-ended responses which involve complex analytical skills. In such courses, students are often required to do substantial practice that needs to be marked by the educator and returned to students before the next lesson.

The context of this paper is a core data analysis course at the National University of Singapore (BN2102 Bioengineering Data Analysis), where students are introduced to concepts relevant to the interpretation and statistical analysis of experimental results in the biomedical engineering field. These concepts/knowledge require students to perform some of the most commonly used statistical analysis of experiments as well as to interpret the results of typical bioengineering experiments by building a suitably fitted mathematical model. With high enrolments of an average of 100 students each year, it is rather difficult for the instructor to address students' diverse needs due to a great variability in their prior knowledge and skills. To provide students with enough practice, standard exercises and the provision of model answers during the next classroom session are adopted. However, two issues were identified using this approach. First, it was observed that students tend to copy answers from each other, without even attempting to examine the process in solving the given problem. Second, though model answers enable students to verify the accuracy of their solutions against the model or ideal solutions, the usefulness is limited as there could be other methods to approaching the same task. Moreover, it has been reported that students prefer personal over standard feedback as the latter were perceived as having "lack of personal empathy and guidance" (Huxham, 2007, p. 608). In domains with well-structured but complex declarative knowledge, studies have reported the sole usage of model answer is not as effective as combining it with elaborated feedback (Collins, Carnine, and Gersten, 1987; Mory, 2004).

To speed up the provision of assessment and feedback, the use of computer-based solutions for the provision of assessment and feedback is a popular option for educators. For feedback to be effective, students need to be provided with timely and targeted feedback on their work (Butler & Winne, 1995; Corbett & Anderson, 2001). Most importantly, instructors need to make informed decisions on how they can adapt their teaching by making best use of information on their students' progress to better close the feedback loop.

The purpose of this paper is to describe the development of a tool, AGStex (Assignment Generation Software using Latex), which enables academics to generate individual assignments tasks and to provide targeted feedback to students in large classes. We will examine what constitutes an effective feedback and introduce the theoretical underpinnings of the tool. Using a combination of both automated and manual assessment, we will describe how the instructor goes about providing extra feedback to address the learning gap faced by students. Finally, we will discuss the limitations of this conceptual paper and to suggest further work needed to inform the impact on the types feedback generated by AGStex on students' learning outcome.

Literature review

Computer-based assessment for complex cognitive tasks

In recent years, there has been a surge of research demonstrating that the use of computer technology to provide assessment and online feedback produces significant benefits (Timmers & Veldkamp, 2011; Hatziapostolou & Paraskikis, 2010). Other than engaging students to apply the concepts taught in the lectures, automating assessment effectively reduces teachers' grading time by automating the generation of questions, marking of students' work for certain tasks and by speeding up the provision of feedback (Brown, Race, & Bull, 1999, Van der Kleij, Timmers, & Eggen, 2011).

Scalise and Gifford (2006) created a taxonomy of item types in computer-based assessment and discussed the limitations of each of the item types. The item types are namely: (a) fully constrained responses (e.g. multiple-choice items), (b) intermediate constrained responses (e.g. short answer items), and (c) fully constructed responses (e.g. essay questions). They explained that fully constructed responses are better able to diagnose more complex learning processes and promote deep understanding of conceptual knowledge than items with fully constrained responses. In the case of BN2102, students are frequently engaged with problem-solving related tasks that require them to produce fully constructed responses. These problem-solving tasks involve the use of cognitive strategies, such as the selection, application, and evaluation of a cognitive strategy. Although current technology has made it possible for open-ended responses to be done by machine grading with substantial inter-rater reliability with the human scoring (Wiser, Mead, & Pennock, 2016), such technology is not readily available and affordable in most common learning management systems.

Along with the convenience in administering the online quiz, teachers have to deal with plagiarism. Plagiarism is considered a very serious offence in most universities. The detection of plagiarism for large class assignments has always been a difficult task for human graders. In particular, if different teachers are involved in the grading process, the question of reliability comes into play.

Formulation of the written online feedback

Feedback is instrumental for improving quality of student learning performances. Yet, based on a comprehensive review of 87 meta-analyses of studies, Hattie and Timperley (2007) observed that different types of feedback can be differently effective in terms of students' learning performances and levels of attention paid to feedback. They advocate that providing task-related feedback is critical as it will inform students on the correct direction to approach the task, the manner to complete the task, and enhance the effects of self-regulatory behaviour.

Shute (2008) proposed useful insights towards the types of feedback and the design of task-related feedback. Various types of feedback were distinguished by the author, namely: knowledge of results (KR), knowledge of correct response (KCR) and elaborate feedback (EF). In the case of KR, the feedback only informs whether the answer is correct or incorrect. KCR is an extension of KR which aims to revise incorrect answers by providing the correct answer. With EF, students are provided with an explanation for why their response is correct or incorrect, coupled with process related feedback that addresses the method to be followed to complete the task. This cues the learners into a cognitive elaboration process, which enhances deep understanding (Anderson & Reder, 1979). A recent meta-analysis on effects of feedback in a computer-based learning environment by Van der Kleij, Feskens, & Eggen (2015), suggests that EF is most effective as compared with KR and KCR for higher order learning outcomes.

Feedback timing is also an important consideration for auto-generated feedback. Studies were less conclusive about the impact of feedback timing (i.e. immediate vs delayed) on learning outcomes (Shute, 2008; Van der Kleij et al., 2015). Most research is concerned that feedback is timely, where students receive the feedback not before the student is ready to make adjustments in his or her performance or understanding (Corbett & Anderson, 2001). That feedback needs to lead students to revisit the learning activity that led to the feedback is arguably the most important finding regarding the effectiveness of feedback (Butler & Winne, 1995). Given that one of the biggest challenges to computer-based feedback is that students can easily ignore the written feedback (Timmers & Veldkamp, 2011; Van der Kleiji et al., 2015), it is suggested that students will need explicit guidance to benefit from learning opportunities that arises from the feedback.

With the above considerations on what constitutes an effective feedback for higher order learning outcomes and the affordances of an automated assessment tool, a feedback cycle process flow is formulated to guide the educator from the creation of the assignments to the provision of elaborate feedback. The proposed tool, AGStex, is being developed with the following aims:

1. Substitute the one-size-fits-all traditional approach of distributing the same take-home assignment to the entire class with a personalized assignment approach even in large classes
2. Ease the educator's work to provide students with timely, targeted and effective feedback on their work.
3. Try to reduce plagiarism among students

The AGStex application is developed using the C++ programming language and hinges on several open-source software, primarily Latex for the generation of the pdf files.
Figure 1 describes how the feedback is generated to the use with reference to the model of feedback and self-regulated learning, from point A to D, originally published by Butler and Winne (1995). The external feedback responses would have to be interpreted, constructed and internalised by students to have a significant influence on subsequent learning (Ivanic, Clark & Rimmershaw, 2000). This is addressed at Point E where our approach to close the feedback loop is described.

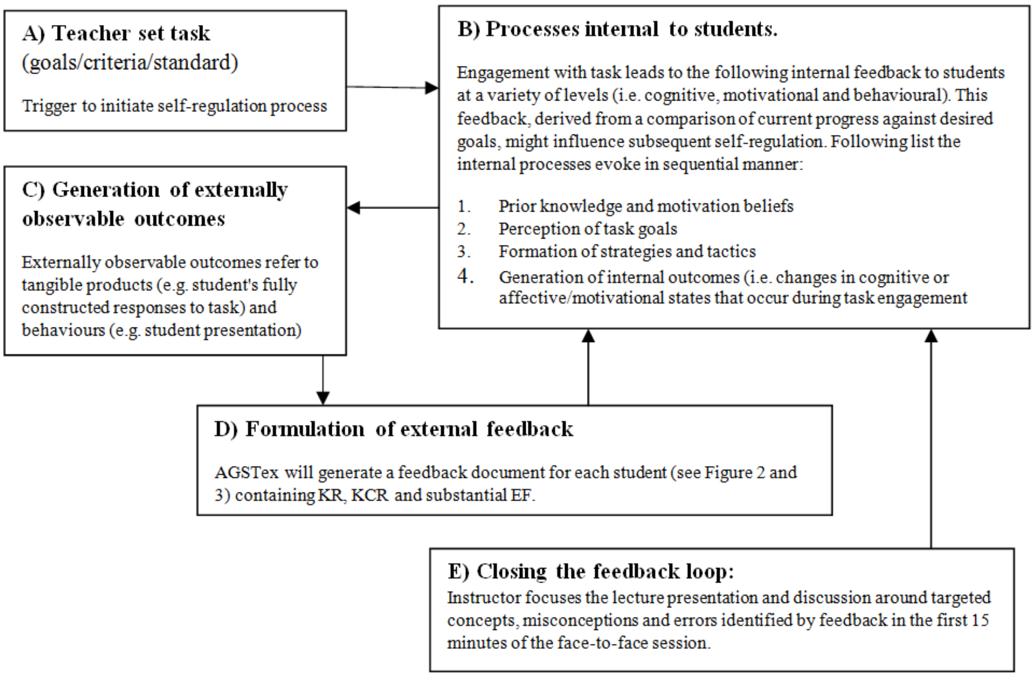

Figure 1: Contribution of AGStex within the model of self-regulated learning and feedback principles proposed by Butler and Winne (1995)

The following section outlines the process of developing the feedback and closing the feedback loop to improve learning using the proposed AGStex tool.

The AGStex tool and design of feedback

The aim of the developing the AGStex tool is to enable the educator to generate a set of individual assignments for topics on data analysis as well as providing personalized feedback distributed students in a timely manner. The objective is to provide each student with individual knowledge of the correct response (KCR) as well as targeted elaborate feedback (EF). Figure 2 shows a schematic representation of how AGStex generates questions and feedback. The educator inputs the following:

1. Textual description of a few contexts used to frame the question
2. Criteria to be used to generate data sets that students will work on, specifying “groups” of data
3. For each context in a), a specific textual feedback
4. For each group of data in b) a targeted feedback and typical mistakes.

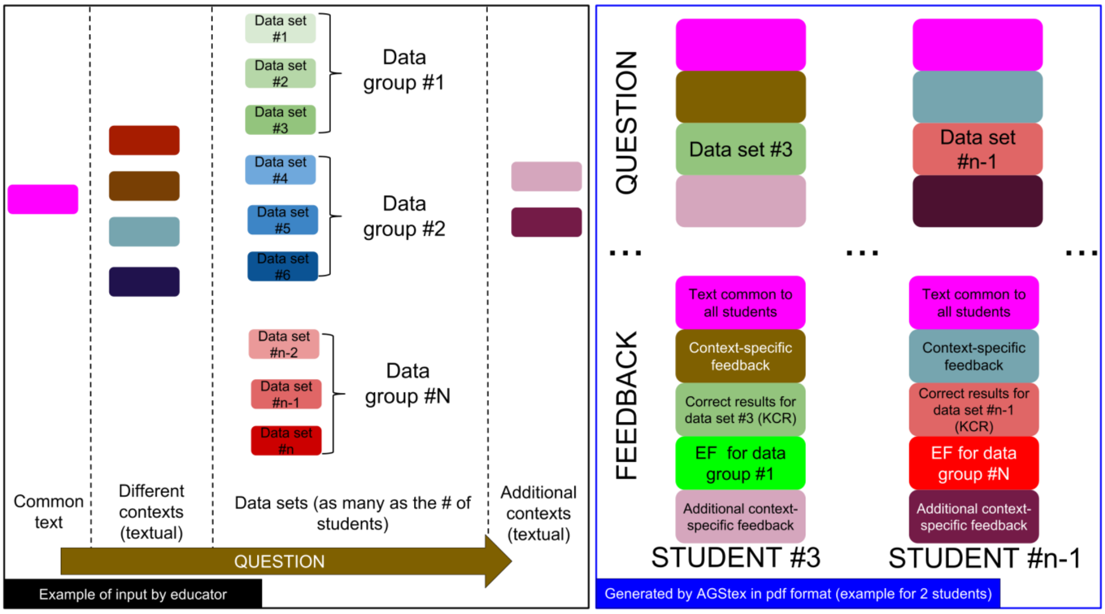

Figure 2. Color-coded schematic representation of educator's input (black box, left) and AGStex output (blue box, right) in the form of unique questions and n feedback documents.

Given these inputs and the required number of students n, AGStex will:

1. Generate n sets of data, keeping track of which “data group” they belong to and perform the required analysis.
2. Generate n unique assignment questions (in pdf format) obtained by randomizing the given set of contexts and assigning one unique data set to each student
3. Generate n unique assignment feedback documents (in pdf format) containing textual context-specific feedback, the correct numerical answers of the data analysis (KCR) as well as the required interpretation and typical mistakes associated with that specific “data group” (EF).

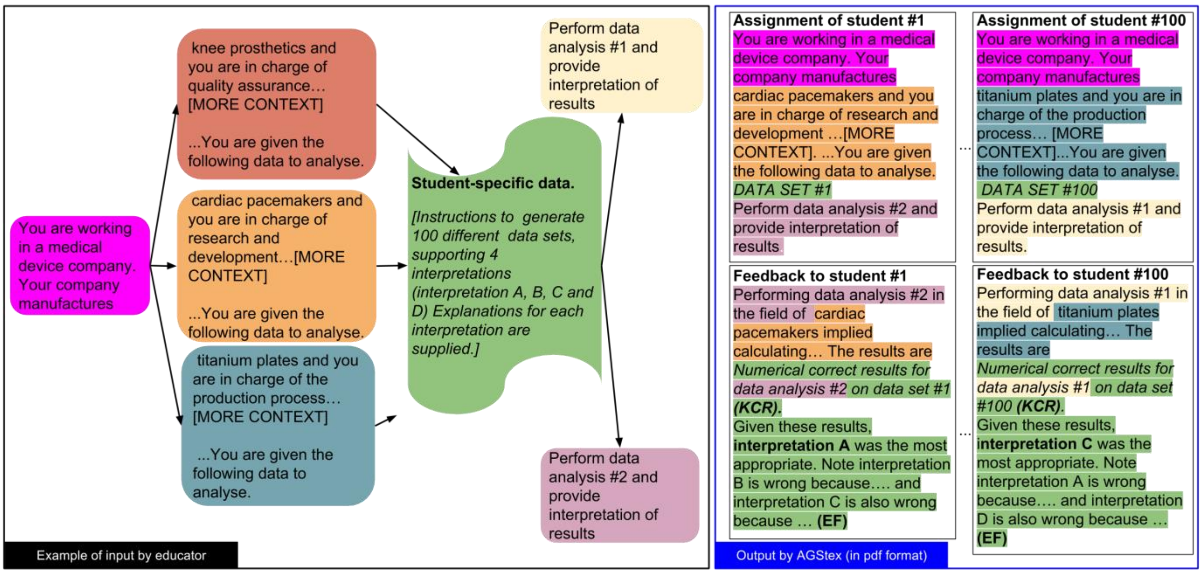

Figure 3. Example of usage of AGStext to generate assignment and feedback for data analysis topics in the biomedical engineering field. In this example, AGStext will randomize the choice of context and the generation of data for each student. It will then generate a feedback document with the correct answer (KCR) and containing specific feedback for the given context and data set (EF).

Taking the BN2102 Bioengineering Data Analysis module as an example (100 students), Figure 3 shows a possible concrete case of assignment and feedback generated for 100 students. Given the inputs, the approach described in Figures 2 and 3 is fully automated. With students receiving different datasets or scenarios, yet maintaining similar complexity level of the test-items, the possibility of students copying the solutions from each other is mitigated.
There are several optional extensions to what is shown in Figure 2 and 3 that AGStex will incorporate to improve the given feedback:

- Given a class roster typically maintained by institutional learning management systems, the feedback document can be automatically generated including the name of the student in the feedback, at any point in the document specified by the instructor, e.g., "Dear John, ". This is an attempt to address the "lack of personal guidance and empathy" (Huxham, 2007, p. 608) typically associated with online assignments.
- The feedback can include graphical elements in the form of charts which will be specific for each data set and automatically generated
- The automatically generated feedback documents described in Figure 2 and 3 are immediately available to the educator. It will be possible for the educator to tweak it manually during the process of marking and add individual feedback for each student manually, if necessary.
- AGStex has the ability to compute and give the correct numerical answer for a particular problem and data set. Provided a suitable format of students' submission, it is also possible to auto-mark the numerical part of the answer to ease the educator's work.

Current progress, limitations and future work

The AGStex tool is being coded by one the authors of this paper. The approach described in Figure 2 and 3 has been preliminary tested for the BN2102 Data Analysis module. The tool is currently functional for certain types of data analysis but lacks a Graphical User Interface (GUI). As such, the only way to use it at the moment is to provide the necessary inputs within the appropriate sections of the source code itself. This is definitely not convenient. Development of a suitable GUI is a fundamental future step as it will allow an educator without knowledge of C++ to use the tool. We also intend to expand the range of numerical analysis that AGStex is able to help the educator with. This would not be limited to the data analysis/statistics field, but can extend to any discipline.
Though we have tested the functionality of the tool for one semester, the research is limited because we did not manage to collect data from students on their perception about the feedback generated. We plan to conduct a formal study by collecting both quantitative and qualitative data to explore students' perspectives about the type of feedback generated by the AGStex tool and to investigate whether by closing the feedback cycle helps students achieve better learning outcomes.

Conclusion

Providing quality feedback and having a process in place to assure that students engage with it is an important consideration in implementing computer-based assessment. Quality feedback needs to be targeted, timely and personalised. In addition, an effective communication method is needed to ensure that students engage with the feedback content. Given the features built into AGStex, we believe the tool can provide added value over standardised assignment tasks and model answers by presenting individualised assignments and targeted feedback.

References

Anderson, J. R., & Reder, L. M. (1979). An elaborative processing explanation of depth of processing. In. L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory* (pp. 385–403). Mahwah, NJ: Erlbaum.

Brown, S., J. Bull, & P. Race. (1999). *Computer-assisted assessment in higher education*. London: Kogan Page.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of educational researc*h, *65*(3), 245–281.

Corbett, A. T., & Anderson, J. R. (2001). Locus of feedback control in computer-based tutoring: impact of learning rate, achievement and attitudes. *Proceedings of ACM CHI-2001 Conference on Human Factors in Computing Systems*, 245–252.

Collins, M., Carnine, D., & Gersten, R. (1987). Elaborated corrective feedback and the acquisition of reasoning skills: A study of computer-assisted instruction. *Exceptional Children*, *54*(3), 254–262. https://www.researchgate.net/profile/Russell_Gersten/publication/19840015_Elaborated_corrective_feedback_and_the_acquisition_of_reasoning_skills_A_study_of_computer-assisted_instruction/links/00463537261f9205e6000000.pdf

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of educational research*, *77*(1), 81–112. https://insightplatform-public.sharepoint.com/SiteAssets/feedback-and-reporting/characteristics-of-effective-feedback/power_feedback.pdf
Hatziapostolou, T., & Paraskikis, I. (2010). Enhancing the impact of formative feedback on student learning through an online feedback system. *Electronic Journal of eLearning*, *8*(2), 51–90.
Huxham, M. (2007). Fast and effective feedback: are model answers the answer?. *Assessment & Evaluation in Higher Education*, *32*(6), 601–611. https://www.researchgate.net/profile/Mark_Huxham/publication/254220135_Fast_and_effective_feedback_are_model_answers_the_answer/links/5579ab9308aeb6d8c02055ad.pdf
Ivanic, R., Clark, R., & Rimmershaw, R. (2000). What am I supposed to make of this? The messages conveyed to students by tutors' written comments. In M. Lea & B. Street (Eds.), *Student writing in higher education* (pp. 47–65). Buckingham, UK: Open University Press.
Mory, E. H. (2004). Feedback research revisited. *Handbook of research on educational communications and technology*, *2*, 745–783. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.610.3249&rep=rep1&type=pdf
Scalise, K., & Gifford, B. (2006). Computer-based assessment in e-learning: A framework for constructing" intermediate constraint" questions and tasks for technology platforms. *The Journal of Technology, Learning and Assessmen*t, *4*(6).
Shute, V. J. (2008). Focus on formative feedback. *Review of educational research*, *78*(1), 153–189. http://myweb.fsu.edu/vshute/pdf/shute%202008_b.pdf
Timmers, C., & Veldkamp, B. (2011). Attention paid to feedback provided by a computer-based assessment for learning on information literacy. *Computers & Education*, *56*(3), 923–930.
Van der Kleij, F. M., Feskens, R. C., & Eggen, T. J. (2015). Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis. *Review of educational research*, *85*(4), 475–511. https://www.researchgate.net/profile/Theo_Eggen/publication/272923307_Effects_of_Feedback_in_a_Computer-Based_Learning_Environment_on_Students'_Learning_Outcomes_A_Meta-Analysis/links/5592911e08ae5af2b0eb335f.pdf
Van der Kleij, F. M., Timmers, C. F., & Eggen, T. J. H. M. (2011). The effectiveness of methods for providing written feedback through a computer-based assessment for learning: a systematic review. *CADMO*, *19*(1), 21–39.
Wiser, M. J., Mead, L. S., Smith, J. J., & Pennock, R. T. (2016). Comparing human and automated evaluation of open-ended student responses to questions of evolution. *arXiv preprint arXiv*:1603.07029. http://arxiv.org/pdf/1603.07029.pdf

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