IFS: An educational platform for analyzing course outcomes and student experience

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This paper introduces IFS, an online discipline-agnostic educational platform for a longitudinal study that explores students' characteristics, their online behavior patterns, and the relationship of those characteristics and behaviors to course outcomes. Initially, automated-assessment tools are available for computer programming and English language writing. Students submit snapshots of course work for assessment and are provided automated feedback. IFS incorporates student self-assessment as an essential component of the system. Student self-assessment options include surveys, such as self-efficacy or Grit, and self-assessments related to their perceived skills or performance. The data collected from the students' surveys and their IFS interactions can be used to explore behavioral trends that impacted course performance and overall experience.

Additional Key Words and Phrases: Formative Feedback, Automated Feedback, Self-assessment, Educational Data Mining, Computer programming

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1 INTRODUCTION

Educators can find it challenging to interact and provide timely feedback to students due to the volume of students and the impossibility of providing individual evaluations. Online courses can exacerbate these challenges with more significant student numbers, a reduction in course-structure, and the lack of any in-person contact or timely personalized feedback. Feedback is considered one of the most critical components of assessment and learning Bandura and Walters [1], Mory [13]. The absence of feedback within a reasonable timeline can reinforce incorrect learning, instigate student frustration, and ultimately lead to student disengagement Mory [13], Shute [15]. To relieve struggling students from further frustration and disengagement, feedback must be consistent, clear, relevant, and timely Mory [13].

Previous research has focused primarily on student performance in terms of learning outcomes, such as grade improvement. However, students extrinsically motivated to learn have been shown to utilize superficial methods of learning, such as memorization to perform the minimal amount required to receive their desired grade [11]. Students set their participation levels based on their motivation, the course material, and personal learning objectives. Thus, the student's perception of their ability and motivation for the learning goals must be understood to effectively help

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the student learn. Self-assessment, whether accurate or not, provides insight into a student's perceived current state. Mitrovic and Martin Mitrovic and Martin [12] referred to self-assessment as a necessary skill for effective learning, a vital part of exploratory learning, and an opportunity for self-reflection.

Our research considers that the current trend towards large class enrollments forces students to become more independent and self-directed. In this learning environment, students require additional management skills to ensure their academic success. As automated educational tools are increasingly used to supplement the disparity between the number of educators and students, it is imperative that self-regulation and formative feedback are used to positively impact the learning process and course outcomes.

The overarching goal of this research is an interdisciplinary longitudinal study to explore the relationships between students' course performance, their online behavior, and their self-assessed experience. Our research team has developed an online educational platform that accepts student's course submissions and performs automated assessments to provide formative feedback. The Immediate Feedback System (IFS) has been developed to offer university students a discipline-agnostic automated feedback platform.

Automated feedback systems can evaluate students' assignments and minimize educator marking overload while allowing students to practice and receive timely feedback to reinforce their theoretical knowledge. Student's personality traits, beliefs, and characteristics impact their interpretation of feedback, and a better understanding is required to identify which student characteristics and behaviors are dictating outcomes. Automated feedback systems that focus solely on evaluations can leave students confused about the expectations of the system and frustrated with the rigidness of the system. Focusing strictly on evaluation restricts educator awareness of the student knowledge and learning process while providing only performance information about students.

The IFS research platform is designed to be a student-centered learning environment that provides formative feedback and allows students to self-regulate their practical learning. The IFS focuses on providing the students with a variety of assessment tools and open data models to reduce learner confusion. During student usage of IFS, the following types of data are collected: interaction-level data, submission-level data, demographic information, and students' self-assessment of their performance.

2 IFS

Student's involvement in the learning process is an essential factor in the architectural design of IFS. Students submit snapshots of their work to the IFS for assessment. They are provided formative feedback based on the assessment tools selected by the student. The IFS dashboard provides open behavioral model information based on open student model research Bull and Kay [4], Bull and McKay [5]. Open student models allow students to monitor and self-regulate their behavior Brusilovsky et al. [3]. Vicarious experience is an integral part of the learning process. The dashboard enables students to view the overall class trends and abstracted behavioral data from other students in the course.

2.1 Architectural Overview

The IFS architecture diagram is shown in Figure 1 it illustrates the main components and processes of the IFS system.

The user interface (UI) is the primary interaction point between the user and the system. Through the UI, a student can set profile preferences, submit files, view submission assessment feedback, and view statistical information relating to their IFS usage. The user-selected assessment tools process the submission files to produce automated feedback. The assessment feedback from all the selected tools is consolidated and personalized. Finally, the feedback is prepared for presentation to the user and displayed on the website. The final component of the IFS is the learner system which

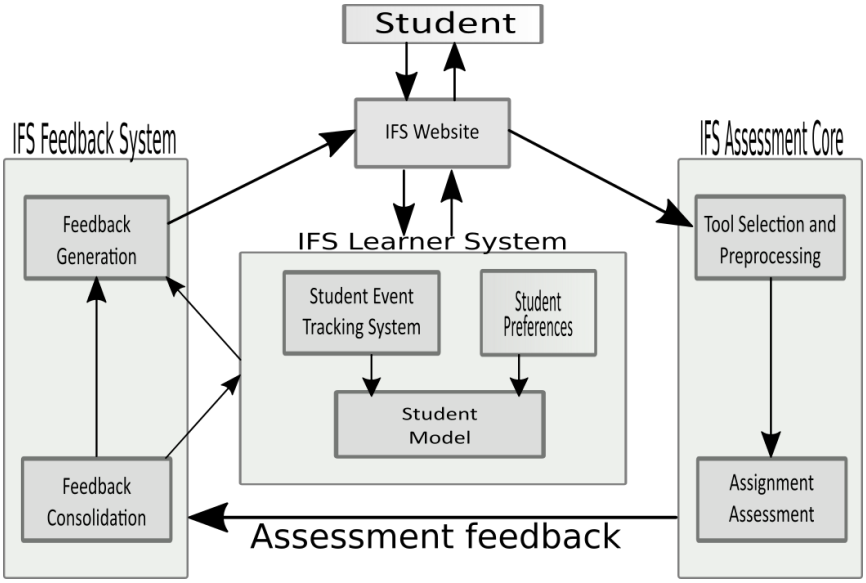

Fig. 1. The figures demonstrates the main components of the IFS architecture, students interact through the website UI. Student's submissions are processed in the assessment core and the assessment feedback is consolidated in the feedback system for personalization on the website. The learner system stores data related to the submissions and student interactions with the feeedback and system.

tracks information about the students' assessments, feedback, and interaction behaviors for research purposes, leader boards, and instructor feedback.

2.1.1 IFS Assessment Core. The IFS assessment core is a customizable pipeline of student selected assessment tools, and these tools provide a range of assessment options. Students choose which assessment tools assess their work through the IFS website during the submission process. Currently, the assessments tool include writing computer programs and English language compositions. These tools dictate the type of feedback the student receives. The software assessment tools can perform a static analysis of the student's code; these tools include but are not limited to using third-party analyzers such as GCC, CppCheck, and Clang. The IFS allows custom assessment tools that perform tasks such as checking submissions against assignment requirements or providing descriptive statistics about their work, such as the number of comments and lines of code. The IFS writing tools provide feedback on written elements such as spelling, grammar, APA bibliography formats, tone, profanity, syntax, or spacing issues. Each assessment tool provides feedback to the core in the form of a JSON object that is easily parsed by the feedback system.

2.1.2 IFS Feedback. The feedback system parses and evaluates the JSON feedback output from all tools and consolidates that information into a clear, concise, and consistent format for use by students. The feedback system incorporates all the feedback from the student selected assessment tools and orders issues based on their general categories. IFS guarantees the student the same minimum level of feedback they would have received by running all tools independently but specific tools can identify common errors and provide additional static feedback with improved readability. The assessment tools statically indicate the severity and category of the feedaback. Once organized, the feedback is passed to the learner system to display to the user, save to the database, and evaluate for inclusion in the student learner model.

2.1.3 IFS User Interface. The IFS provides a consistent user-interface for novice users of both purpose-built and commonly available feedback tools. This feature alone improves the ability of students to obtain feedback on their work.

Course instructors can customize IFS for their course by providing assignment descriptions and objectives, a course specific set of assessment tools, and task breakdowns. Each assignment can be linked to learning outcomes and students can perform self-assessments of their mastery of those learning outcomes. Students can further customize their assessment tools by disabling/enable tools or changing specific options to receive customized feedback.

IFS processes student submissions in real-time while the student waits. During the processing of submitted work, the IFS presents the student with an optional short pulse survey of 2 questions. These question are selected in a continous manner from a set of surveys described in 2.2.2. Students may complete the pulse survey or proceed directly to the feedback page.

The student's original work is used as the base for presenting the feedback to the student. Sections of their work that are relevant to specific feedback items are visually highlighted and the feedback is presented as a layer over the original text. The feedback page provides options to view all the feedback items at once or only that from specific tools. Additionally, a student may view descriptive statistics about their submissions with information such as word count, number of lines, or number of comment count. A student may select any highlighted feedback item to review additional information and suggested solutions to resolving errors that may have caused a particular feedback item.

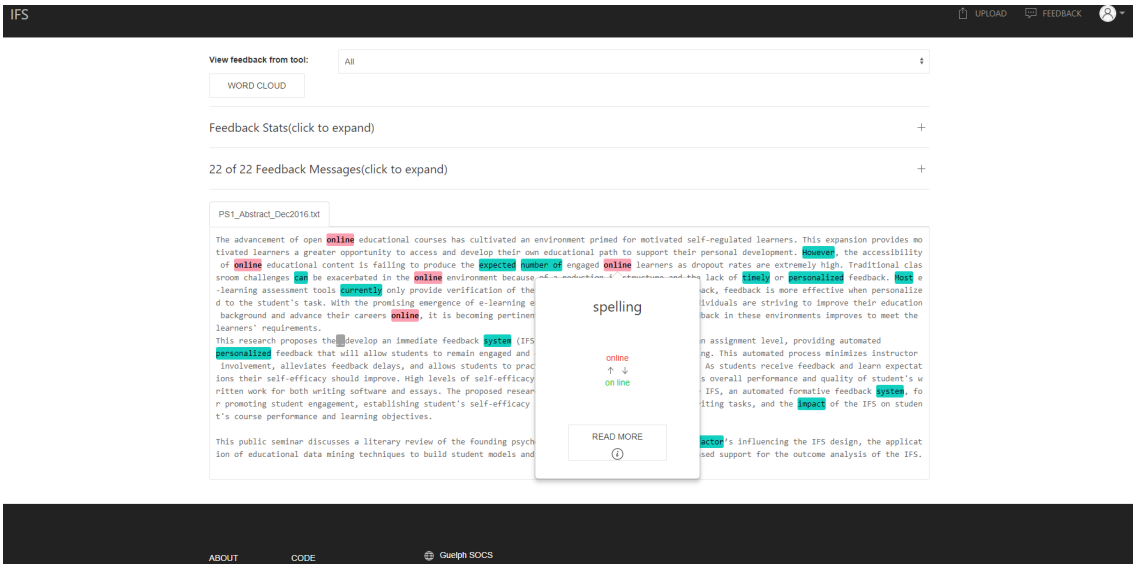

Fig. 2. The feedback page enables students to view their initial submission that has been marked up with highlights to text items with assessment feedback. Students may select any highlighted item to receive a summary or suggestion or may choose 'Read More' to view more elaborate feedback. Visual tools, such as a 'Word Cloud' are also accessible.

2.1.4 IFS Learner Model. The student model stores personalized information about the student, including information about their preferences, self-reported mental state, self-assessments, submissions, and assessments. Student information is gathered during their interactions with IFS and any self-assessments such as survey responses. The IFS is designed to be open about interaction data stored that students may partially inspect via the dashboard. Currently, the students have access to key metrics about their past learning performance, which supports their self-reflection and development.

The student has access to aggregated data from the entire class to observe the trends for critical metrics of the whole class.

2.2 Data

The IFS stores and mines demographic information, self-assessment, survey responses, and interaction data. Our research focuses on the interaction between student behavior, self-assessments, and performance. The demographic information collected is limited to age, gender, course, and year of study. Future studies may wish to include more detailed demographic data collection.

2.2.1 Self-Assessment. Instructors can provide skills or knowledge components for student self-assessments based on the specific learning outcomes of the assignments or the course. Students can rate their understanding from 0-100 as often as desired during the course. Student can observe their self-assessed progress throughout the semester in the dashboard. Our research investigates when students chose to perform self-assessments and the relationship of those self- assessments to the feedback they received for submitted work.

2.2.2 Survey . Surveys play a vital role in understanding student's characteristics, mental state, and course experience. Direct surveys of students involves them in the learning process and allows them to express their thoughts. All IFS surveys are 5-point Likert-scale and range from 10-30 questions, in which students self-assess their characteristics or experience.

Students are requested to complete surveys at the start and end of the course as part of a pre/post survey analysis. All surveys are accessible at all times if a student wishes to re-do a survey.

Currently, the IFS utilizes several surveys related to course motivation, engagement level, and the student's characteristics or personality traits. Example surveys included in the research are self-efficacy [2, 10, 14], GRIT Duckworth and Quinn [7], SCEQ Handelsman et al. [9], OSE Dixson [6], and AGO Elliot [8].

Pulse surveys are used for online engagement and may be collected with each submission or at any point through the menu UI. IFS users are not required to submit survey responses and may opt-out entirely. All survey have been reviewed by the University of Guelph ethics board [REB-17-08-004].

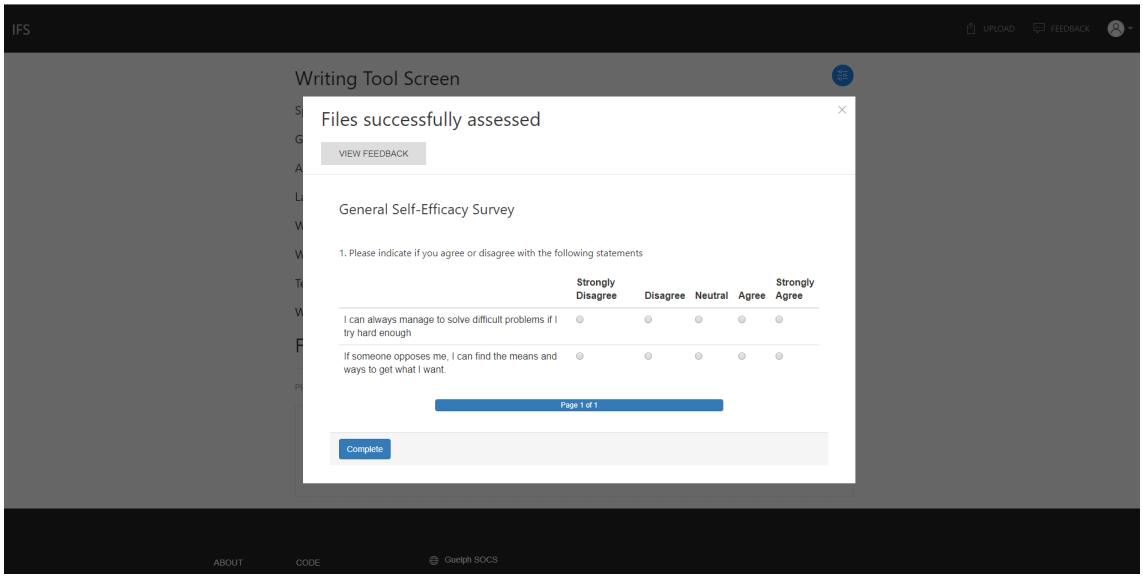

Fig. 3. Example version of a user interface for pulse surveys. A student may choose to complete a maximum of 2 questions or bypass the survey to view their feedback.

2.2.3 IFS Interaction Data. Interaction data is collected as metrics that fall into these broad categories: session data, submission data, assessment data, feedback interactions and views, and learner model interactions. A full description of the interaction metrics captured is beyond the scope of the paper (but is available on request). Session metrics relate to when a student is online; it includes the time and frequency a student is online. Submission data contains the original submission and information pertaining to the quality, rate, and details of the student's online submissions. Assessment metrics correspond to the submission and include the feedback produced by running all of the assessment tools. Feedback metrics are the student's interaction with the feedback generated during the assessment. The interaction metrics represent the student interaction with the formative feedback process.

3 FUTURE WORK

Our initial research experiment was conducted in the 2018/19 school semester in targeted first and second-year university computer science and psychology courses. This research project will continue in the upcoming year(s) in the same courses and will be expanding into new courses in 2019/2020. This research will focus on providing open-access to the IFS platform and integrated tools via GitHub at https://gitlab.socs.uoguelph.ca/feedback/IFS . Additionally, our focus will be to align with the data-sharing goals of the SPLICE project to provide researcher's opportunity to explore the collected data.

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