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Mining informal and short weekly student self-reflections for improving student learning experience

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Completed Research

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Abstract

Having students write short self-reflections at the end of each weekly session enables them to reflect on what they have learned in the session and what concepts they find challenging. Analyzing these self-reflections provides instructors with insights on how to address the missing conceptions and misconceptions of the students and appropriately plan and deliver the next session. In this paper, we study the impact of informal and short weekly self-reflections on students' learning. Our methodology includes an approach to effective collection and mining of the textual reflections based on Google survey forms and TIBCO Spotfire. To evaluate our research questions, we apply the approach to a second-year computing course. We present both qualitative and quantitative analyzes of the findings. We also present the dashboard design useful for gaining insights with interactive visuals that aid in classroom interventions. The results in terms of student and faculty feedback on the process and a strong positive correlation between learning and grades show the effectiveness of this approach in improved learning experiences over weeks.

Keywords

Self-reflections, informal and short text, text analysis, student suggestions, dashboard.

Introduction

Self-reflections have become an essential component in higher education that provides the opportunity to help students develop confidence in their learning as they establish learning goals and eventually take ownership of their learning (Noels et al., 1999; Park, 2003). Analyzing these self-reflections can further help instructors identify students who are struggling with their learning and support them in narrowing the learning gap.

Reflective thinking helps find solutions to problems in situations that are highly undetermined (Thorpe, 2004). It aids to investigate what occurred, critically analyze experiences to make informed decisions, and test their validity. Given that reflection places emphasis on personal experiences, learning becomes personalized. Therefore, it is an act of active learning compared with the passive absorption of lesson content. Reflective writing is used as an educational tool in many disciplines. The most traditional self-reflections formats include journals, directed writings, discussions, and portfolios whereas, the new formats include; videos, weblogs and audios using reflection annotation tools. Instructors may engage the students in self-reflection activities in classrooms, but it is not often habitual. With all the challenges faced in teaching the content and assessing learning outcomes, it is very common for the instructor to skip the reflection activity, thus losing an opportunity to allow students to take responsibility for their learning. One approach to build reflective practice into a class session is by encouraging students to record their thoughts about what they have learned at the end of a class session. This can be achieved through the use of mid-term or end of lesson short reflections using directed questions (Dobrovolny & Lowenthal 2011). In this

article, we share our experiences with collecting and analyzing such self-reflections that are informal and brief in nature.

In order to gain useful insights from student self-reflections, the instructors adopt qualitative and quantitative content analysis methods. The type of content analysis used is dependent on the form of reflection writing (e.g. audio, text) and the purpose of analysis (Noels et al., 1999; Marefat , 2002). The most common purpose of content analysis involves the discovery of insights into certain categories that indicate the students' status. The frequently used categories include: description of an experience, awareness of feelings, awareness of one's personal perspective, having a critical stance, considering other perspectives, and the description of learning outcomes. In this article, our content analysis focus is to gain insights into two categories: students' learning experiences and specific directions for classroom interventions.

While analysis of self-reflections provides important insights about student's learning experience, it is a time-consuming manual process. In most cases, it involves the use of manual qualitative content analysis on a student's reflection write-up. With advancements in the field of text mining, there have been some attempts to use more automated methods. Textual content is usually analyzed with text analysis methods or language aspects methods, which help to detect insights about the students' learning journey. Videos and audios require more advanced techniques (Cheng & Chau, 2009). Machine learning approaches have been employed by several researchers to analyze student feedback and reflections such as topic models and classifiers (Chen et al., 2016; Ullmann, 2019; Gottipati & Shankararaman. 2017). Many other related works have applied machine learning for binary classification of reflective statements (Ming et al., 2019). Most of the previous works focused on long or medium articles and mostly structured and grammatical.

In this research study, our approach differs from earlier works in terms of the specific insights we seek to obtain namely topics of the course that the students are reflecting upon, the learning experience ratings, and suggestions for improvements by sections and by weeks. Such discovery enables us to identify the challenging topics, and easy topics in the course and aids the faculty in planning interventions such as, when should the instructor require to prepare additional material or spend more time on weekly recaps. We also aim to use simple techniques that can be easily adopted by faculty with some background in data visualization tools. We seek to answer the following research questions:

RQ1: Do informal and short weekly self-reflections boost students' participation levels?
Amidst numerous concurrent courses, assignments, and deadlines, students may be hesitant to partake in reflection writing as it can be time consuming (O'Connell & Dyment, 2011). This can result in students not wanting to continue writing reflections. Instead, our approach seeks to elicit student feedback by means of specific guided questions. In place of longer formal self-reflections, our students write shorter informal self-reflections which provide faculty with a wealth of actionable insights for better lesson planning.

RQ2: Do insights into formal and short weekly self-reflections give faculty-specific directions for improving course content and delivery?
Reading through a large number of student reflections and deriving insights can be a painstaking process as it requires manual efforts. Our study suggests that an interactive dashboard with visuals can help ease this process by automatically mining insights from students' self-reflections and making suggestions for improvement.

RQ3: Do informal and short weekly self-reflections improve the learning experiences of students?
For self-reflection to be a meaningful activity for students' enhanced learning experiences, it is important for faculty to assess its effectiveness. Is self-reflection yet another 'things to do' for students or is it really beneficial to students? Our approach gathers weekly feedback from students on their perception of their learning experiences.

RQ4: What is the correlation between students' learning experiences and their grades?
To assess the statistical significance and strength of the relationship between students' learning experiences and their performance on formal course assessments, our study performed correlation analyses - which we present in Section 4.

Our research methodology includes design and collection process for self-reflections followed by analyzing insights for classroom interventions. We developed a weekly student self-reflections analytics dashboard using TIBCO Spotfire and shared it with the students as well during the weekly recap sessions. The dashboard provides the below insights to the faculty:

1. What the challenging topics, statistics, and example reflections for each topic?
2. What the enjoyable topics, statistics, and example reflections for each topic?
3. What is the learning experience of the students by weeks and by sections?
4. What are the suggestions given by students by the week and by section?

To develop the dashboard, we first gathered the requirements from the faculty and their pain points in analyzing the student reflections. We then applied simple dictionary-based text-matching techniques to align self-reflections to topics and then built a dashboard template with the features visualizing the insights. At the same time, the tool is user friendly that the faculty have to follow the same simple recipe every week, to analyze and use the reflections for course improvements.

In the next section, we present the related work. We subsequently present process and dashboard design, dashboard analytics, and qualitative and quantitative studies to answer research questions. Finally, we conclude in the final section.

Related Work

Self-reflections Characteristics & purpose

Characteristics: Self-reflection is a key activity and a type of thinking that leads to better learning (Dewey 1933) defines that "reflective thinking is an active, persistent, and careful consideration of a belief or supposed form of knowledge, of the grounds that support that knowledge, and the further conclusions to which that knowledge leads." Based on his theory, instructors and researchers proposed two modes, various formats and various purposes for student reflections. Modes of reflection are either individual or team based. In individual mode, the students reflect on one's own experiences. In team based mode, throughout a course, students in teams reflect together on their teamwork experiences (Veine et al., 2019). The formats of self-reflections include: journals, portfolios, essays, discussions, structured survey questions (Dobrovolny & Lowenthal, 2011), videos, audios, weblogs, etc. (Michaela 2012). Reflections can be informal or formal. Formal reflections include reflective essays and is usually backed by reference evidence. In informal reflections, students are expected to simply respond to a series of structured questions and there is no requirement to formally reference the work (Dykes & Meyer, 2018; Dobrovolny & Lowenthal, 2011)

In our course, we focus on informal short self-reflections at the end of a weekly session, we use the term informal-short-reflections work as suggested by Dykes & Meyer, (2018). The main purpose is to get closer to students' needs by gaining insights into the topics and concepts that the students find challenging and encourage high participation.

Purpose: Reflections are adopted in the class for various purposes. According to (Noels et., 1999), goal-setting and proactive use of strategies are logical outcomes of the reflective process. In many cases, reflections enable shifting some of the learning responsibilities from the instructor to the learner. According to (Fahimeh, 2002), reflections provide insights into students' learning process and to get closer to learner needs. Park indicated that learning journals have the potential to assist the introspective examination of the students' learning behavior process (Park, 2003). According to Amulya, reflections provide the course characteristics from the students' angle and serve the educators to develop efficient pedagogical practices (Amulya, 2004).

Machine Learning in Self-reflections

Analysis of self-reflections is conducted using both qualitative and quantitative modes. Reflective thinking frameworks (Wallman et al., 2008; Kember et al., 1999) provide a structured process to guide the act of reflection. When reflections are structured in this way, instructors can analyze these reflections more efficiently. Machine learning and Natural language processing (NLP) are becoming popular techniques that are used in automating the analysis of student feedback and reflections (Liu et al., 2019; Nitin et al, 2015). Ullmann et al. (2012) developed a rule-based system for reflection analysis in students' blog postings using NLP techniques. Gibson et al. (2016) used part-of-speech (POS) tagging to analyze student writings. Kovanovic et al. (2018) developed a classifier with an elaborated feature engineering process to categorize reflections into various predefined classes.

In our approach, we combine key phrase extraction techniques (Keyword Extractor, 2020) with a data visualization tool to analyze reflections and gain insights along two dimensions: course topics or concepts and student's learning experiences.

Self-Reflections Process and Dashboard Design

In this section, we present the reflections data details, weekly process, and dashboard design.

Metadata

To mine the self-reflection, we need two types of data as shown in Table 1.

1. Student self-reflections: This dataset consists of datetime, the students' demographics, and their feedback. Students take 5 minutes to complete the Google form survey.
2. Course Content: This dataset consists of the course's weekly outlines (chapters) and slides content. There are 10 weekly outlines in total.

Data Type	Columns
Weekly self-reflections data	1) Timestamp 2) Name 3) Class Section 4) List one topic of the class that you enjoy 5) What is the most challenging topic? 6) Overall, the learning experience for the class. 7) How do you suggest to improve the class?
Weekly course outline	Introduction to BPM, Process Modeling, Process static analysis, Process dynamic analysis, IT Requirements, Solution architecture, Process Architecture, Process Innovation, Business IT alignment

Table 1: Metadata for analysis of weekly self-reflections

Weekly self-reflections collection and analysis process

The weekly steps for the faculty is a simple and repetitive recipe as shown below.

1. Faculty setup Google based reflection survey
2. Students submit the weekly self-reflections
3. Faculty analyse the reflections with Dashboard
4. Faculty adjusts the course based on the suggestions
5. Faculty share summaries and insights in class every week
6. Faculty and students discuss key challenging topics

Dashboard Data

Based on the course content, the dictionary is created for sub-topics using key phrase extraction which is one time task. The dictionary consists of the week, topic, and related key phrases. For example, "use case", "actor", "UML" are key phrases for the sub-topic "use case model" which falls under the chapter, "IT Requirements". Figure 1 shows the sample key phrases for the slide content of "IT Requirements" using MonkeyLearn (Keyword extractor, 2020).

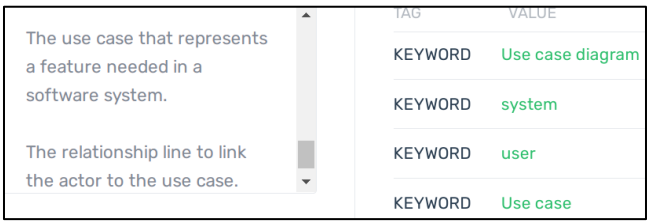


Figure 1: Key phrases extraction example

Dashboard Template: We create a sample dashboard using TIBCO with the interactive visuals described in Section 1; challenging topics, enjoyable topics, statistics, learning experience ratings and comparisons, and suggestions.

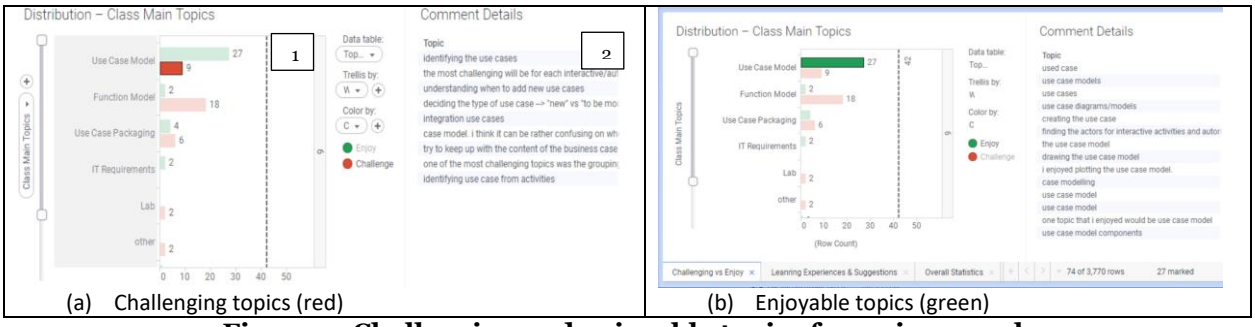
Dashboard Weekly Updates: The dashboard updates consist of two major stages. The first stage is the alignment of reflections to topics using the dictionary and text matching. The second stage is feeding the reflections data file to the predefined TIBCO template. The course manager performs this task weekly and shares with the faculty teaching other sections of the same course.

Dashboard features

Challenging topics and Enjoyable view

To enable the faculty to understand the challenging/enjoyable topics for the given chapter, the visuals in Figure 2 provide the ranked list of topics (1) and the corresponding comments (2) on the right.

Figure 2 shows the topics for week 6 in chapter, "IT Requirements". The data used for this view is from columns 4 and 5 of the self-reflections row in Table 1. The interactive feature enables faculty to select specific topics and analyze the comments in detail. The view aids faculty to understand key learning challenges of students and adjust the weekly recaps or run additional tutorials.

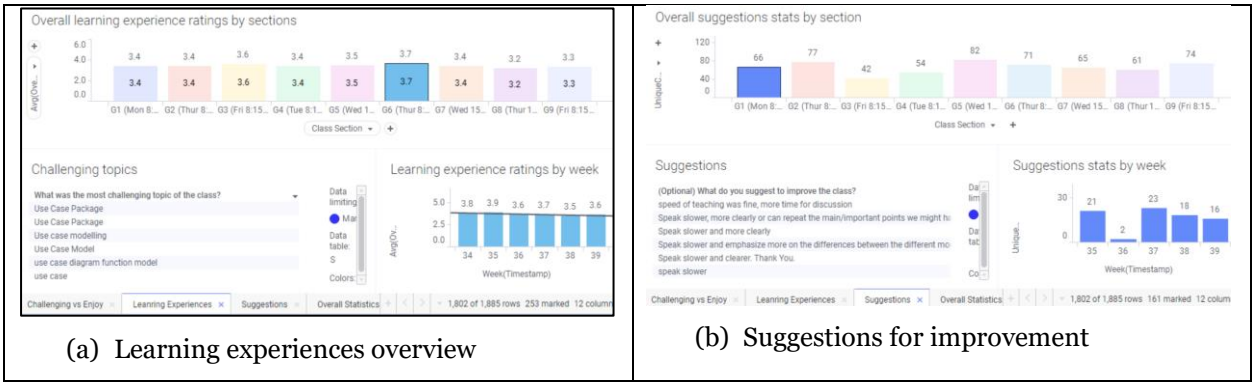


(a) Challenging topics (red) (b) Enjoyable topics (green)

Figure 2: Challenging and enjoyable topics for a given week

Learning Experiences View

Recall that one of the questions in self-reflections is ratings on learning experience (column 6 of the self-reflections from Table 1. This view provides multidimensional information; by section (1), week (2), and the corresponding challenging topics (3) as shown in Figure 3a. The insights aid to compare learning across multiple sections and provide more support to the sections with low ratings. It also provides weekly trends to observe if faculty interventions are effective or not.



(a) Learning experiences overview (b) Suggestions for improvement

Figure 3: Learning experiences and Suggestions for improvement for a given week

Suggestions for improvement view

Column 7 of the self-reflections in Table 1 captures students' suggestions for course improvements. Similar to the previous view this view provides multidimensional information by section (1), week (2), and presents the suggestions (3) as shown in Figure 3(b).

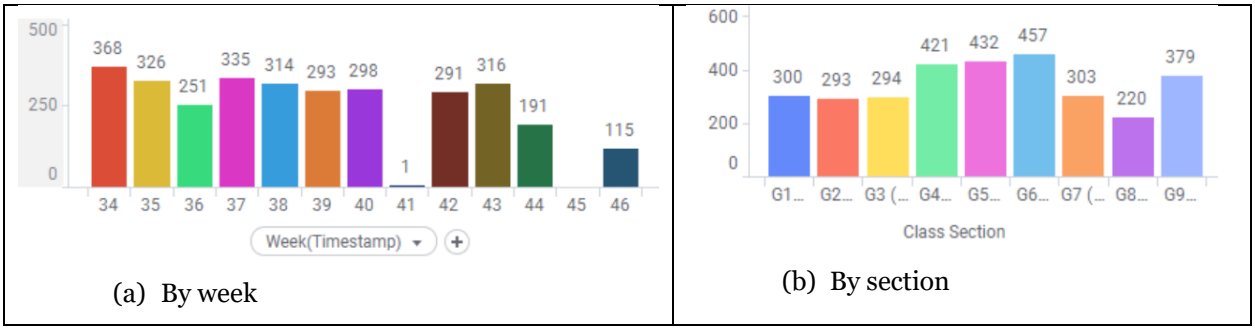
The insights aid to view and compare the statistics. Together with the previous view, it provides more insights into the learning journey of the students. It also provides weekly trends to observe if faculty interventions are effective or not.

Dashboard analytics - Quantitative studies

In this section, we present the quantitative analysis of self-reflections for an undergraduate course *Business Process Analysis and Solutioning* (BPAS). BPAS is a compulsory year 2 course for computing students in our school. We first present the overall statistics of the reflections followed by the impact of the reflection analytics in classroom settings. We also studied the correlations of the grades to the reflections to understand the dependency of reflections on the grades.

Overall self-reflection statistics

Figure 4 shows the overall statistics by week and section. We start the course in August every year where the course is scheduled for 13 weeks. Week 34 of the year represents the first week of the class. Week 41 (the eighth week of the class) is a break week with no planned lesson. Week 45 (the 12th week of the class) is allocated for project consultations (and no lesson is planned this week). We also observe low numbers in Week 45 (the 11th week). This may attribute to fact that this is the last lecture, and the perception is that faculty are not going to use it for class improvements. Lastly, we observe low numbers in Week 46 (the 13th week of the class) as it is the student group project presentation week. We use 9 weeks for the analysis of students' participation.



(a) By week

(b) By section

Figure 4: Overall statistics of self-reflections for a term

Section G8 has the lowest number because of the small class size but other sections are equally distributed in terms of class size. We have around 40 students in each section and a total of 373 students in this study.

The average number of reflections is 310 per week excluding weeks 8, 12, and 13 (82.2%). All students participated at least once and 91.8% of students participated 5 times or more in 9 weeks time frame (30% of students participated all weeks). On average, each student participated 7.5 times in 9 weeks with a standard deviation of 1.5.

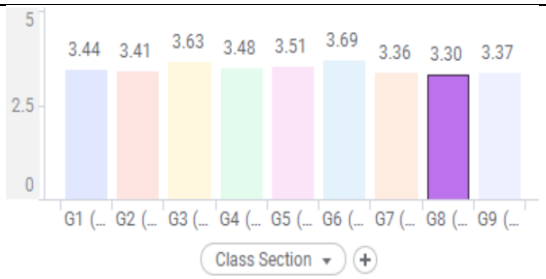
To answer **RQ1**, the statistics indicate that our students are highly motivated to complete the weekly self-reflection. A majority of our students consistently participated in writing informal and shorter self-reflections which are less time consuming than longer and deeper formal reflections.

Analysis of learning experiences

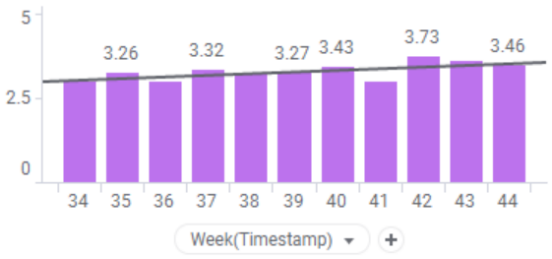
From the learning experiences view, we observe that sections G3 and G6 have higher average learning experience ratings (3.63 and 3.69 respectively - on a scale of 0 to 4) as shown in Figure 5(a).

Section G8 has the lowest learning experience rating. This is consistent with their final course grades. Figure 5(b) shows that throughout the term, students' learning experiences increase *even though the overall learning experience rating is lower than in other sections*. The same trend is observed in all other sections where the learning experience rating increases as the term progresses.

To answer **RQ3**, students benefit from participating in informal and short weekly self-reflection writing as indicated by increasing learning experience rating from the first lesson all the way to the last lesson.



(a) Average learning experience ratings by section.

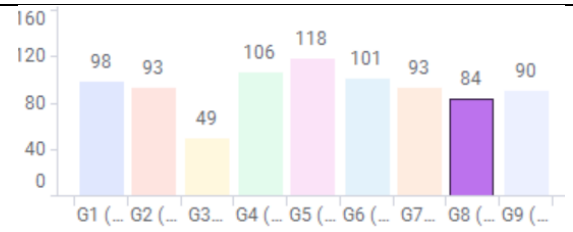


(b) Learning experience rating trends for section G8

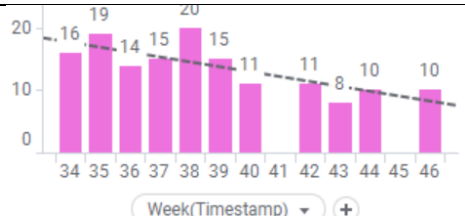
Figure 5: Analysis of learning experiences for term

Analysis of suggestions

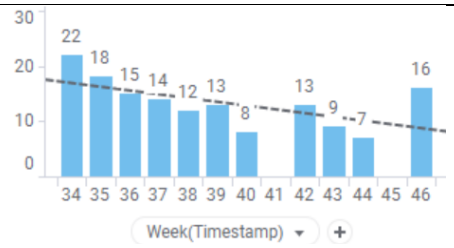
From the suggestions view, we observe that section G5 provided the highest number of suggestions as shown in 6(a). Additionally, we notice that the number of suggestions is more or less consistent with an average of 15 suggestions per week as shown in Figure 6(b). The suggestions from G5 are usually very innovative ideas such as 'use kahoot', 'prepare lab video tutorials', etc.



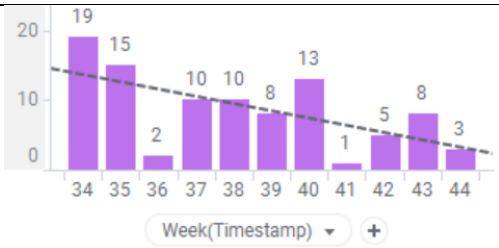
(a) Overall suggestions statistics by sections



(b) Suggestions statistics trend for section G5



(c) Suggestions statistics trend for section G6



(d) Suggestions statistics trend for section G3

Figure 6: Analysis of suggestions statistics for a term

We also observe that the suggestions by sections G3 (Figure 6(c)) and G6 (Figure 6(d)) have a falling trend. In general, as the learning experiences improved, the number of suggestions reduced over time, indicating the success of faculty interventions.

Correlations with grades

At the end of the term, we studied the correlations of grades with self-reflections. Many studies suggest quantitative correlation analysis approaches (Carr & Johnson. 2013). Figure 7 shows the combined learning experiences ratings and distributions of students over the grade scale of 11 used in our school. We observe a bell curve for the grades distribution and one failure for the course. No student scored the grades D or D+.

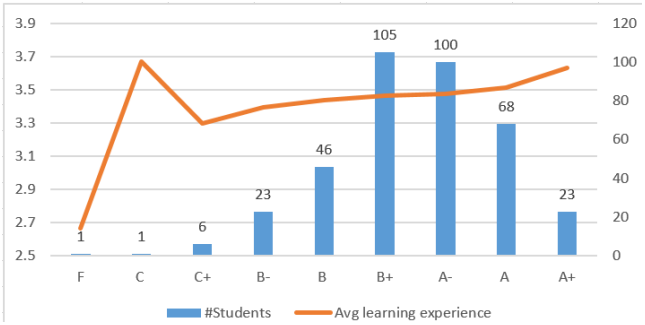


Figure 7: Correlations analysis of grades – with learning experiences and with suggestions

Correlation of grades with learning experience ratings: From Figure 7 we observe a growing trend of learning ratings. The average learning experience (average of ratings) across all sections and weeks is 3.39. Pearson correlation between the grades and the learning experience is 0.708 indicating a strong positive correlation. To answer **RQ4**, the correlation coefficient indicates that there is a positive relationship between students' learning experiences and grades.

Correlation of grades with average suggestions: We are also curious to analyze the correlations between suggestions and grades. Pearson correlation between the grades and the average suggestions (number of suggestions/number of students per grade) is equal to -0.590 indicating a negative correlation. In other words, the students who receive high grades provide fewer suggestions. A further study in this area can be future work.

Feedback on self-reflections - Qualitative studies

Student feedback

Recall that more than 82% of students participated in the self-reflections regularly. This indicates that the students are highly motivated to complete the task every week as they see that it is simple and useful. We received positive feedback and teaching ratings are high compared to previous years. Below are comments;

"Prof … love to gather feedback from the class and know their understanding which makes the class able to at least clarify their doubts before the next lesson starts."

"The instructor was very well versed in the topic and also took in the feedback given by students on a weekly basis and made the necessary adjustments."

To answer **RQ3**, informal and short weekly self-reflections improve students' learning experiences. Students' feedback points to an important element of our approach and that is the way the faculty can quickly yet comprehensively understand students' concerns by using the interactive dashboard and devise necessary interventions (such as extra revision on selected topics in the following week's lesson).

Faculty feedback

Three faculty teach this course with ownership of certain sections and one of the faculty is in the role of course manager.

Manage student-learning process:

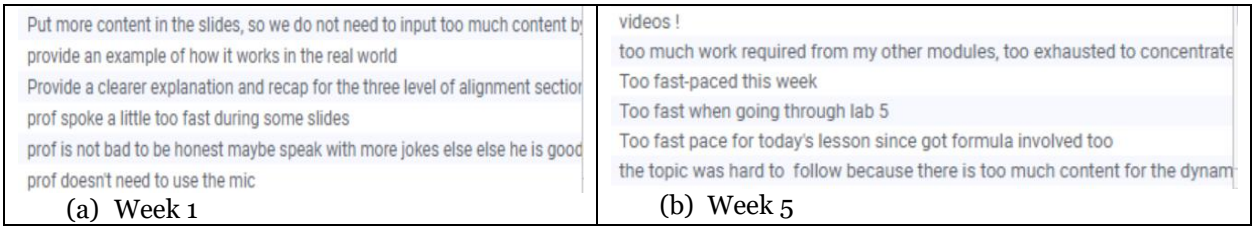
(Faculty) "I have a very good understanding of the students learning process every week"

For example, during the IT requirements chapter (week 6), the students have problems with use case modeling. In particular, we can see the problems are about identifying use cases, deciding the type of the use case, and integrating the use cases into a single model following UML. This helps the faculty have not just high-level information about learning but also a deeper understanding of cognitive skills development.

User-friendly and quick insights for class interventions:

(Faculty) "Dashboard gives me clear directions of where the course requires adjustments."

For example, we noticed that in the early part of the course, more suggestions are about improving the presentation style and content sharing whereas the later parts are about the content difficulty aspects.



(a) Week 1 (b) Week 5

Figure 8: Sample suggestions from students

Week 1: Figure 8(a) shows some suggestions from Week 1. Based on this, the faculty added some notes to the slides and added some simple real-world articles for reading. We also observe that some comments are personal sentiments, *"…too exhausted to concentrate"*. For such comments, we do not take any action.

Week 5: Figure 8(b) shows sample comments for week 5. Based on the suggestions, we run the following recap session with the lab 5 details and formulas used for process analysis. We created the videos during break week for the later part of the course, which is process innovation.

To answer **RQ2**, our faculty finds the interactive dashboard with informative visuals to be an effective way of understanding the insights mined from informal and short weekly self-reflections by their students. Such insights effectively guide faculty to intervene in the class planning and delivery.

Process and tool improvements:

Our research has limitations in terms of the impact of faculty digital literacy background and student learning profile on the findings. To address these issues, we propose some future work to this study.

Simplification of the process: In the current process, the Google form setting is one-time step but the data extract, transform and load (ETL) is repetitive. This also requires some technical knowledge background for faculty. The faculty propose the simplification of the process where the data can be directly pulled from the Google form to the dashboard.

Individual student analysis to aid personalized learning: The faculty is unable to analyze individual student's personalized learning journey. Additional features to the tool on the student personalized learning can be useful to provide targeting help and support the student's learning process.

Conclusion

In this article, we present a structured approach for the collection and analysis of informal and short students' weekly self-reflections. In this paper, we study the impact of informal self-reflections on students' learning process. We evaluated our methodology in second year computing course. The main contributions of this article are the design of the self-reflections and the design of the dashboard for user-friendly and interactive display of the insights mined from the textual content. The process and design are simple and can be easily adopted by the faculty with some foundations in using visualization tools such as Tableau or TIBCO. Further, our team is working on improving this dashboard with more features as suggested by the faculty. Our solution can be adopted in any courses that regularly collect self-reflections from students. Our current work focuses on English-written self-reflections in an Information Systems course where self-reflections do not contain any special characters or notations such as mathematical equations or computer programs. For such courses, we plan to create domain-specific corpora (e.g. common PHP functions or Python libraries/functions used in our Information Systems courses) with which our solution can detect reflection phrases that contain domain-specific terms. Lastly, we see great potential in this area for research related to machine learning applications for learning and teaching process improvements.

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