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Analysis of online posts to discover student learning challenges and inform targeted curriculum improvement actions

Michelle L. F. CHEONG
Singapore Management University, michcheong@smu.edu.sg

Jean Y. C. CHEN
Singapore Management University, jeanchen@smu.edu.sg

Bingtian DAI
Singapore Management University, btdai@smu.edu.sg

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Michelle LF Cheong
School of Information Systems
Singapore Management University
Singapore
michcheong@smu.edu.sg

Jean Y-C Chen
School of Information Systems
Singapore Management University
Singapore
jeanchen@smu.edu.sg

Bing Tian Dai
School of Information Systems
Singapore Management University
Singapore
btdai@smu.edu.sg

***Abstract*—Past research on analysing end-of-term student feedback tend to result in only high-level course improvement suggestions, and some recent research even argued that student feedback is a poor indicator of teaching effectiveness and student learning. Our intelligent Q&A platform with machine learning prediction and engagement features allow students to ask self-directed questions and provide answers in an out-of-class informal setting. By analysing such high quality and truthful posts which represent the students' queries and knowledge about the course content, we can better identify the exact course topics which the students face learning challenges. We have implemented our Q&A platform for an undergraduate spreadsheets modelling course, and analysed 1025 meaningful posts to identify the hot areas represented as topic tags, map the identified hot tags progression over time, to direct instructors towards targeted improvement actions. Our proposed approach can be applied to other courses where students' self-directed Q&A can be implemented.**

Keywords—online posts, Q&A platform, learning challenges, topic level curriculum improvement

I. INTRODUCTION

Almost every university will conduct end-of-term survey to collect student feedback to enhance the quality of teaching and learning. Usually, both qualitative and quantitative feedback are collected on three main aspects, namely instructor teaching style, course content and student learning experience. There were conflicting reports in terms of whether student feedback will contribute to improved teaching. An early piece of work [1] reported that student feedback did contribute to improvement in teaching, and the improvement will be more significant when supplemented by expert consultation because 'feedback provided was too vague and nonspecific to be useful for improvement' and usually the instructor will not know what needs to change to bring about improvement as highlighted in [2]. On the other hand, reference [3] commented that there is 'no evidence that the use of the questionnaires was making any contribution in improving the overall quality of teaching and learning', and they explained that 'it is possible that feedback from the questionnaire was not used effectively.'

Two recent pieces of work [4], [5] argued against relying on student feedback as an effective measure for teaching effectiveness and student learning. Specifically, [4] analysed the student evaluations of 116 business related courses and found 'little and no support for the validity of student evaluations of teaching effectiveness (SETEs) as a general indicator of teaching effectiveness or student learning'. [5] added that 'student evaluation of teaching (SET) instrument currently used fails to provide a valid measure of teaching quality as it does little to measure the extent of students' actual learning.' Such disparate views in the literature warrant proper analysis and use of the student feedback to serve its intended purpose in teaching and learning improvement.

With the aim to analyse students' qualitative comments but faced with the difficulty in manual analysis, the researchers in [6] developed the Student Feedback Mining System (SFMS) which employed text analytics and opinion mining to assess the student qualitative feedback for seven university level courses, to provide insights for the instructors on their teaching practices, leading to improved student learning in the next teaching cycle. First, they used agglomerative clustering technique to group the students' comments into clusters, and then used the highest frequency words in each cluster to determine a high-level topic (e.g. faculty interaction, project, assignment, labs, skills, concepts understanding, and learning experience) for each cluster, and then finally extracted the student sentiments towards each topic. The result was a sentiment analysis bar chart (positive or negative) for each high-level topic. A similar piece of work [7] was performed using the Latent Dirichlet Allocation (LDA) method on sentiment analysis to analyse the qualitative feedback for 183 courses into nine user-defined high-level topics, to allow each student feedback to be tagged with more than one topic, representing an improvement over the work done in [6] which was limited to just one topic. While both pieces of work provided the instructors with an understanding of the students' sentiments towards each high-level topic, they still did not point the instructors to specific learning challenges that can be addressed directly.

More recent works [8], [9] applied text mining and visualization techniques to extract implicit and explicit suggestions from students' qualitative feedback comments respectively, and encouraged instructors to combine them with the quantitative scores to 'amend the course with more informed evidences on the specific components of the course'. Both pieces of work were similar in the solution approach in using text pre-processing and text classification models, and only differed in terms of extracting implicit versus explicit suggestions. Their work represented a marked improvement from past works which provided only non-specific feedback such as 'the instructor speaks too fast', or 'the course is too difficult'. They extracted implicit and explicit suggestions such as use 'I would prefer more case studies' or 'provide more programming examples', which can lead to the instructor adding more case studies and programming examples into the course content. While both work resulted in actionable improvements, they were still unable to identify

specific learning challenges related to specific course topics, and thus which course topics will need more improvements than others for future deliveries.

We propose to use an alternate data source, which is the online discussion posts, to assist course instructors to understand students' learning and identify learning challenges. Analysis of online discussion posts have been done in the past to achieve several objectives such as to discover promising ideas and how these ideas transition over time [10], to model learners' cognitive, affective and social processes [11], and to inform the development of LA application for online discussion [12]. The novelty of our work comes from analysing students' posts created over the entire course duration, rather than end-of-term student evaluation, to uncover true insights into students' learning challenges, leading to actionable improvements at course topic level, to improve future deliveries. In essence, we hope to answer these research questions:

- Through the analysis of the discussion posts, are we able to identify the main topics (represented as topic tags) where students met with learning difficulties?
- By tracking the tags from the posts contributed from week to week, are we able to determine the topics which students face challenges over a longer period of time, and thus need more reinforcements actions and repetitions?
- From the analysis, are we able to recommend specific curriculum improvement actions targeted at specific course topics?

II. Intelligent Q&A Platform

Reference [13] compared the learning-related uses of online discussion forum with mobile instant-messaging app for 78 teachers in China. They discovered that 'using the online discussion forum resulted in more communication aimed at knowledge construction, while using the mobile instant messaging app resulted in more social interactions. Our proposed Q&A platform is designed with two integrated sub-systems, Telegram Application (available in Android and iOS) and Web-based Forum to achieve both knowledge construction and social support. This platform allows the students to ask questions and provide answers using Avatar identities via both interfaces, which are synchronized in real time. The Avatar identities allow students to participate without the fear of being ridiculed, as we encourage students to ask questions and provide answers based on their own viewpoints and knowledge.

Figure 1 shows the schematic of the system architecture. The Telegram Application which can be programmed to prompt students, include customized buttons, and automate interactions via a chat-bot (which we have called it our 'CAT bot'). The Web-based Forum is a full functionality platform which allows students to post questions and answers, view and search for posts, and to view user statistics including thoughtfulness scores earned, in-game coins earned, and leader board ranking. Leader board ranking and in-game coins are meant to inject gamification into the process of learning, and together with our chat-bot which can post periodic questions, they can motivate students to participate and remain engaged. The in-game coins will allow the students to 'buy' quick responses to their questions, and any unanswered question will be automatically routed, to prevent the situation where posted questions which are not answered will lead to loss in interest and engagement, and the eventual failure of the system [14], [15]. Students' posts will be assessed by the Machine Learning (ML) Algorithm linked to the Q&A Corpus for the thoughtfulness score prediction. Thoughtfulness is a term used to describe if a statement (question or answer) contains insightful reasoning and relevance to the issues discussed [16]. The ML Algorithm and the Telegram API are linked directly to the main database, and the Telegram API is also linked to a Question Bank for the chat bot to ask periodic questions automatically.

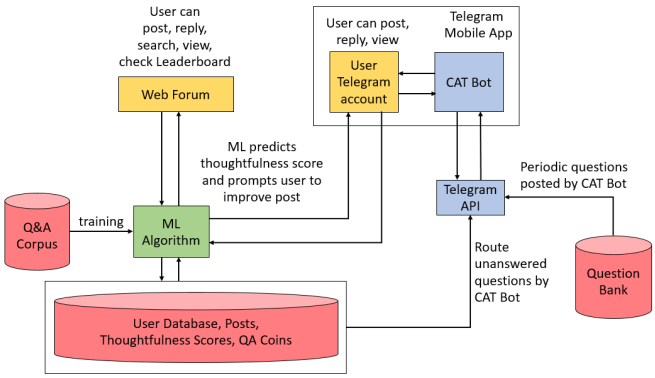

Fig. 1. Schematic diagram of the Q&A platform

We have tested several machine learning algorithms, and the random forest algorithm was selected to predict the thoughtfulness score of the questions and answers posted. Details of the entire data analytics process including data preparation, text pre-processing, feature selection, models and comparison are described in our earlier paper [17]. If the question or answer scores a low thoughtfulness value, the student will be prompted to improve the post. The student will attempt to add more clarity in the question or answer post, by providing examples, compare and contrast scenarios, or explain with greater details. Students' thoughtfulness scores earned throughout the 15 weeks will form part of their class participation assessment in the course, and will also be used in the Leader board ranking. Our platform's engagement enhancement features has led to higher number of posts and higher quality posts which can truly represent the students' queries and knowledge about the course content, as discussed in our earlier paper [18].

III. The Spreadsheets Modeling Course

We have successfully implemented our platform three times, in Spring 2018, Fall 2018, and Spring 2019, for 128, 147 and 360 students respectively, for an undergraduate course in spreadsheets modelling. This course, affectionately known as the 'CAT Course', covers spreadsheets engineering, spreadsheets modelling, and data analysis, and conducted using about 20 spreadsheets models out of a total of 100 created by the authors of the textbook [19] used in the course. This course is delivered over a 15-week duration, where the first seven weeks will cover a wide-range of themes and class exercises (see Table I), followed by a 1-week break in week 8, and then from Week 9 to 13, students will work on their group project to deliver a complete solution model with data analysis using the spreadsheet tool, and to recommend solutions and decisions. Week 14 and 15 are meant for revision and a 2-hour final exam respectively.

To answer the research questions, it is thus important to understand the themes and class exercises covered in this course, so as to link the posts generated by the students to the course content, in terms of their respective topic tags. We tagged each post manually with a maximum of three most appropriate tags, selected from a list of 112 pre-defined tags (see Table I). We have used this manual tagging method based on the instructors' expert knowledge rather than discovering topics from the posts themselves, as such discovery tend to be noisy and will not link to the specific context of the course [20]. The 112 pre-defined tags are organized into five main types:

- Excel functions which can perform specific computations (represented as bold and italic) e.g. ***MAX***
- Tools and functions which are in-built in Excel to perform special tasks (represented as bold) e.g. **Solver** and **Data Table**
- Names of class exercises (represented as underlined) e.g. Alex Processing
- Key concepts related to mathematical theory (represented as italic and underlined) e.g. *PDF* which is the probability distribution function in probability theory
- Assessment components (represented as italic) e.g. *Assignment*

TABLE I. WEEK-BY-WEEK THEME, EXERCISES, ASSESSMENTS AND TOPIC TAGS

W	*Theme, Exercises, Assessments*	*Assessments & Topic Tags*
1	Basic Modeling * Retail Gasoline * Alex Processing * Achilles and Tortoise	***ABS, SUM, AVERAGE, MAX, MIN, COUNT, COUNTA, TREND***, **Fill, Auto-Fill, Referencing**, Retail Gasoline, Alex Processing, Achilles and Tortoise, *Assignment*
2	Spreadsheet Engineering * Multiplication Table * F1 Night City Race * Village Coffee	***IF, Nested IF, ROUND, ROUNDUP, ROUNDDOWN, INT, SLOPE, INTERCEPT***, **Trendline, Goal Seek, Solver**, *Objective Function*, *Decision Variables*, Multiplication Table, F1 Night City Race, Village Coffee
3	Financial Functions * Time Value * Black-Scholes * Charity Donation	***PMT, PV, FV, RATE, NPER, IRR, NPV, MATCH, LN, EXP, NORMSDIST, ISODD, ISEVEN, ISTEXT, ISBLANK, SQRT***, **Data Table, Conditional Formatting**, Time Value, Black-Scholes, Charity Donation
4	Data Lookup and Linkup * Echo Office Supplies * CCH Kindergarten Assignment 1 Due	***LOOKUP, VLOOKUP, HLOOKUP, MATCH, INDEX, SUMIF, CONCATENATE, SUMPRODUCT***, **Solver**, *Objective Function*, *Decision Variables*, *Constraints*, *Solving Methods*, **Data Validation, Array Formula**, Echo Office Supplies, CCH Kindergarten, *Assignment*
5	Monte-Carlo Simulation * Monte Hall * Data Simulation * Frequency Distribution Quiz 1 Due	***IF, Nested IF, RAND, RANDBETWEEN, SMALL, LARGE, PERCENTILE,*** **Uniform,** ***NORMSDIST, BINOMDIST, BINOM.INV, CRITBINOM, POISSON, EXPONDIST, LM, FREQUENCY, COUNTIF, CONCATENATE***, *PDF*, *PMF*, *CDF*, *CRF Table*, Monte Hall, Data Simulation, Frequency Distribution, *Quiz*
6	Time-Based Simulation * ABC Services * XDB Bank * Timer Clicker * Grand Grocery	***RAND, RANDBETWEEN, PERCENTILE, LN, TODAY, NOW, YEAR, MONTH, DAY, DATE, TIME, HOUR, MINUTE, SECOND, TEXT***, *Date/Time Formats*, **Pivot Table/Chart**, ABC Services, XDB Bank, Timer Clicker, Grand Grocery
7	Introduction to VBA * IntroVBA Assignment 2 Due	**IFERROR, ISNA, ISERROR**, *Group Project, Assignment*
9	Group Project Proposal Due	*Group Project*
10	Project Consultation Quiz 2 Due	*Group Project, Quiz*
11	Data Analysis * Kolmogorov Smirnov method * Data Fit * Hotel Apex * Yankee Fruits	***AVERAGE, MAX, MIN, STDEV, LN, NORMINC, NORMSINV, CRITBINOM, BINOM.INV***, **Array Formula**, *CDF*, *Group Project, Revision/Sample Exam*
12, 13	Project Presentation Group Project Due	*Group Project*
14	Revision Week	*Revision/Sample Exam*
15	Final Exam	*Revision/Sample Exam*

IV. PILOT IMPLEMENTATION AND RESULTS

The analysis reported in this paper was based on the posts collected during our pilot run in the Spring 2018 for 128 students over a 15-week period. We collected 1025 self-directed and authentic posts, comprising of 170 questions and 855 answers. We plotted a heat map (Figure 2) to display the top 26 topic tags, each with at least 26 occurrences. Topic tags with fewer than 26 occurrences are ignored as they are less than 20% of the student number, which mean that such tags are not as frequently discussed.

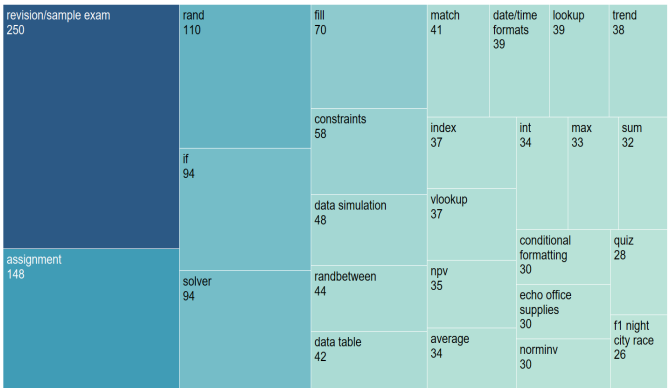

Fig. 2. Heat map of top 26 topic tags

We discuss the top few hot tags below and provide example question and answer posts that demonstrate how the students learn and interact on the Q&A platform:

- The two 'hottest' tags are *Revision/Sample Exam* occurring 250 times, and *Assignment* occurring 148 times. This is not unexpected as students will use the platform for out-of-class discussions on assignments and sample exam revision questions because they are directly related to their assessment components and will have direct impact on their overall grade. This is in fact a behaviour which is desirable because peer learning and support are the main goals of having such out-of-class active discussions. Students did not share solutions to the assignments outright because they

knew that the course instructors were able to view all the discussion posts.

Question: *Can I clarify for Assignment Q3 part h) add a column take-home pay, is it possible to use $L10-$M10-$N10-$O10 instead of L10-SUM(M10:O10)?*

Answer: *I think both methods are okay, just that using L10-SUM(M10:O10) is more concise, easier to read, and would be more suitable for more complex situations (e.g. when there are more than 4 cells to subtract).*

- The next two 'hot' tags are ***RAND*** (110 times) and **Solver** (94 times). ***RAND*** is related to Monte-Carlo simulation while **Solver** is related to using Solver tool to determine the optimal solution to an optimization model. Both tags belong to advanced topics which many students will find them challenging and thus discussed a lot about them. The other related functions are *Constraints* (related to **Solver**), Data Simulation and ***RANDBETWEEN*** (both related to ***RAND***) occurred 58, 48 and 44 times respectively.

  Question: *May I ask if uniform distribution formula is min+RAND()*(max-min) or RANDBETWEEN(min,max)?*

  Answer: *For simulating data, min+RAND()*(max-min) is for inverting continuous distributions while RANDBETWEEN(min,max) is for inverting discrete distributions.*

  Question: *In the last question, we are required to set 4 constraints in solver. Under revised price list, may I check why do we need to set the constraint "$L$6:$N$10<=$L$5:$N$9"?*

  Answer: *From the question, the price must decrease with the increase of quantity purchased. By specifying the constraint "$L$6:$N$10<=$L$5:$N$9", excel will compare L5 with L6, L6 with L7, L7 with L8 and eventually make L10<L9<L8<L7<L6<L5, which is a descending column.*

- The next 'hot' tag is the ***IF*** function. This is a rather surprising discovery. For many instructors, the ***IF*** function is one of the most basic Excel functions and would not expect students to find it hard to understand and apply. However, the tag analysis showed otherwise. This could be due to the complexity involved when one performs ***Nested-IF*** function which can assess multiple test conditions. Thus, instructors should spend more time and effort to explain the ***IF*** and ***Nested-IF*** functions in future.

  Question: *How do we use the IF-THEN-ELSE statement in Excel? Specifically, what kind of problem does it allow us to use this statement? What's the interpretation of ELSEIF and ELSE?*

  Answer: *IF-function tests a condition, IF true THEN perform <action 1>, ELSE (i.e. false) perform <action 2>. When we have more than 1 condition to test. IF <condition 1> THEN <action if condition 1 is true> ELSEIF <condition 2> THEN <action if condition 2 is true> ELSE <action if condition 2 is false> END IF. ELSE is usually used when the condition is false whereas ELSEIF is, loosely speaking, putting another if-statement inside / testing for another condition.*

- The sixth 'hot' tag is **FILL**. In Excel, **FILL** is used to perform repeated computations for multiple cells where the same formula will be repeated into the new cells with automatic update of cell references. The complexity in using **FILL** is in the $ sign which has to be added to the appropriate cell reference at the correct position. It can be quite a mental gymnastics for some students who may face difficulty in understanding where to add the $ sign for effective **FILL**. This shows that more time and effort need to be spent to explain **FILL** clearly.

  Question: *For the Proto part, please check C11$C$4*B11. Is it not necessary to add $ to lock C? Basically, C11C$$*B11 is also correct, right?*

  Answer: *I think it is also correct to not lock C, i.e. C11C$4*B11 as the formula is filled vertically downwards and hence the column would not change.*

- The seventh 'hot' tag is **Data Table**. In Excel, **Data Table** is used to perform repeated computations in a table with one or two variables which can have different values arranged along the top row and/or the left most column of the table. The complexity in using **Data Table** is the concept itself where the Row Input Cell and/or Column Input cell have to be selected, and students often found it bizarre as to how the computations actually occur. This again shows that more time and effort need to be spent to explain **Data Table** clearly.

  Question: *For the Data Table practice in Echo Office Supplies under Widgets F41: H55, can I know what are the row and column inputs?*

  Answer: *You would have to create a dummy cell for number of widgets. Then the formula of the data table will point to the unit price for cell G42 and total charge for H42. The row input cell is empty since it is a one-variable data table and the column input cell is the dummy cell which you put the number of widgets.*

- Other 'hot' tags include ***MATCH***, ***LOOKUP***, ***INDEX***, and ***VLOOKUP*** which belong to the lookup functions in Excel occurred 41, 39, 37 and 37 respectively. Instructors tend to consider these lookup functions to be rather challenging for students but they proved to be less challenging than the simple ***IF*** and **FILL** functions. This is a rather surprising discovery.

  Question: *In the Sample Exam Q1, for cell G13, is there any drawback to using IF(B13"SMU",LOOKUP(E13*24,$A$4:$A$7,$C$4:$C$7),LOOKUP(E13*24,$A$4:$A$7,$B$4:$B$7)) instead of the INDEX & MATCH formula that was given in the model answer?*

  Answer: *It should be fine as well, and is a good alternative to INDEX-MATCH-MATCH. However, LOOKUP gets increasingly tedious if there were more than 2 groups (SMU, Others and 1 more group) and in this case, I would probably favour INDEX-MATCH-MATCH over using LOOKUP.*

- For the longest time, most course instructors shared the same belief that the topic on Financial Functions will be challenging for the students. However, from the tag analysis, only one financial function ***NPV*** which occurred 35 times was discussed. While it is a 'hot' tag, it is ranked 17th among the top tags. Again, this is another rather surprising discovery.

  Question: *Judging by how NPV can be used to evaluate if we should take a loan or should we pay for our purchase upfront, is there a way the question can be changed to use IRR instead?*

  Answer: *Positive NPV means that a business should take up the investment because it increases the value of the company. IRR is the MINIMUM RETURN RATE needed for the business to take up the investment (i.e. NPV = 0). IRR of 11% means that Company X needs a return of at least 11% to take up the project. So yes, there is technically a way for the question to ask for IRR instead.*

From the heat map analysis, course instructors will now know the top 26 topic tags which are high priority to spend more time and effort in future, while the remaining topic tags are normal priority which will be those that students can learn quite well based on the current course design. Without this analysis, instructors may never know that seemingly simple topic tags like ***IF*** and **FILL** should be emphasized.

V. Progress of Hot Topics Over Time

In this section, we track the top 26 hot tags from week-to-week, to understand the progress of the learning challenge. In Figure 3, the size of the bubbles represents the frequency of occurrence for a specific hot tag in a specific week. Particularly, we note that there was almost no bubble recorded in Week 11 and Week 12, as the students were busy with their group projects and the discussion forum was extremely quiet.

Focusing on the top six tags with sizeable bubbles (representing high frequency of occurrences) and/or multiple bubbles spread over an extended period of time (representing long period of discussions), highlighted as red boxes in Figure 3, we discovered the following:

- *Revision/Sample Exam* discussion started only in Week 9, and intensified in Week 14, as the final exam was in Week 15. This shows that students started revision from Week 9 onwards but had to stop in Week 11 and Week 12 due to group project commitment, and resumed discussion slightly in Week 13, and intensely in Week 14.
- *Assignment* discussion started in Week 2 and continued to Week 3 and Week 4, as Assignment 1 was due in Week 4. Then the discussion started again in Week 5 and intensified in Week 7, as Assignment 2 was due in Week 7. There was almost zero discussion on Assignment from Week 8 onwards, as there was no assignment due after Week 7.
- ***IF*** function was introduced in Week 2 and the discussion continued all the way to Week 10.
- **FILL** was introduced in Week 1 and the discussion continued all the way to Week 10.
- **Solver** was briefly introduced in Week 2 and taught mostly in Week 4. The discussion on Solver started in Week 2, continued to Week 4 and then continued all the way with intensified discussions in Week 7 and Week 14.
- ***RAND*** function was first introduced in Week 5 and its discussion started in Week 6 and then continued all the way with intensified discussions in Week 7, 9, 13 and 14.

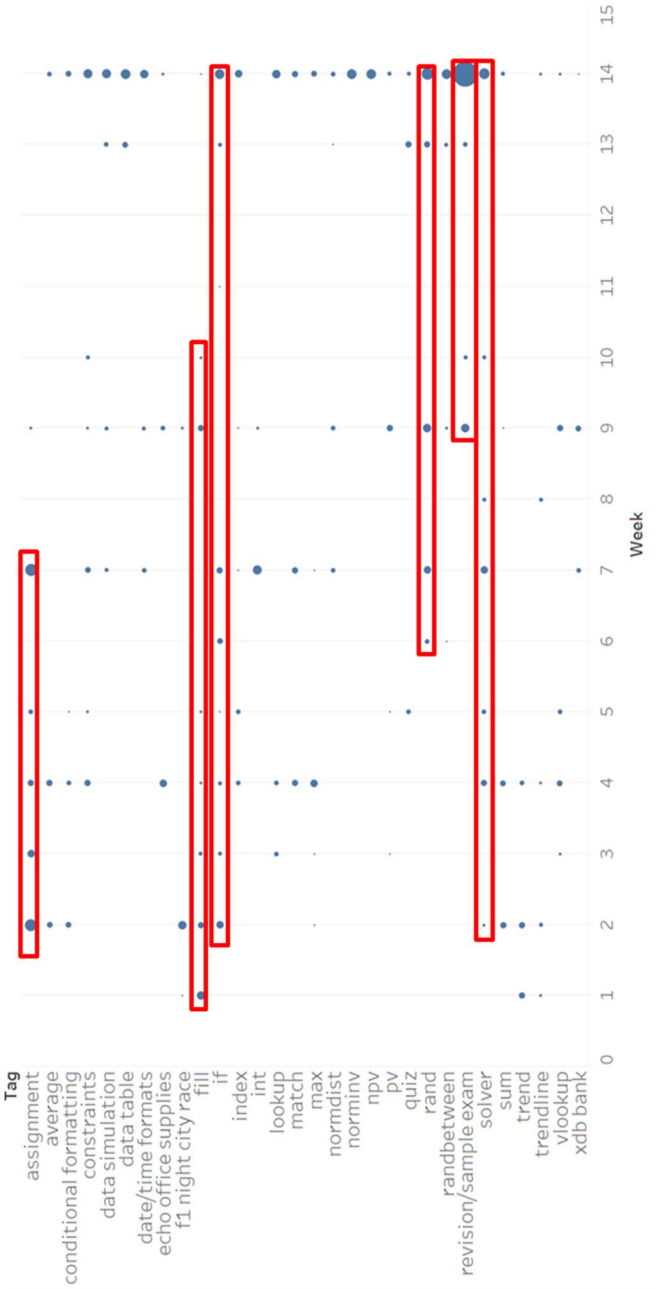

Fig. 3. Temporal chart of top topic tags

From the analysis, we can see that some topic tags were long-lived which represented tags that posed continuous challenge to the students over a longer period of time, while others are short-lived and discussion about them occurred intensely (big bubbles) over a shorter period of time. *Assignment* and *Revision/Sample Exam* were short-lived and discussion about them occurred only during the periods before the assessments and exam were due, which was consistent with what would be expected of students' behaviour.

On the other hand, the ***IF*** function and **FILL** were long-lived. It shows that these functions are commonly used in many of the exercises and assignments, thus discussion about them kept resurfacing. To assist the students to learn them better, instructors can design multiple small revision questions which test the students on these two specific functions, and be given to the students over several consecutive weeks, along the line of reinforcement learning approach to achieve 'practice-makes-perfect' outcome.

For **Solver** and ***RAND*** function, the discussions were rather long-lived and at the same time they belong to the advanced topics which relate to many other topic tags such as *Constraints*, Data Simulation and ***RANDBETWEEN***. Instructors can design more complex revision questions that encompass the related functions, one set for Solver and its related functions, and a second set for ***RAND*** and its related functions, so that students can learn to apply these functions collectively to problem solving in a holistic manner. The instructor can also spend time to go through the Data Simulation class exercise again.

CONCLUSIONS

Analysis of end-of-term student feedback tend to yield only high-level course improvement suggestions or improvements which are limited to high-level actions. We proposed an alternate approach to analyse the online posts contributed by students in an informal Q&A platform over the entire course duration to understand student learning and discover learning challenges so as to inform specific curriculum improvement actions at course topic level. We have implemented our platform for an undergraduate spreadsheets modelling course, and analysed 1025 meaningful and authentic posts using pre-defined topic tags.

With the insights obtained, we are able to answer our three research questions. Firstly, with the top 26 topic tags, we can identify the main topics where students met with learning difficulties. Secondly, our temporal chart tracked the top 26 tags from week to week, allowing us to identify topics which students face challenges over a longer period of time and/or students tend to engage in high intensity discussion, and thus require more reinforcement actions. Finally, we are able to recommend specific curriculum improvement actions targeted at specific course topics which can include (i) prioritize and allocate more class time for the top 26 topics; (ii) design small revision questions to be given to students over consecutive weeks for commonly used functions (such as ***IF*** and **FILL**), and (iii) design complex revision questions for advanced functions (such as **SOLVER** and ***RAND***) for students to apply these functions collectively with related functions to problem solving in a holistic manner. Our approach can be applied to other courses where students' self-directed Q&A can be implemented. Our work can be extended in future to include real-time tagging of posts which can enable real-time analysis, so that instructors can take almost immediate improvement actions during the term, rather than only for future deliveries.

REFERENCES

[1] H.G. Murray, "Does evaluation of teaching lead to improvement of teaching?", *The Int. Journal for Academic Development*, vol. 2, no. 1, pp 8-23, 1997.

[2] H.G. Murray, "Acquiring student feedback that improves instruction. In M.G. Weimer (Ed.), Teaching large classes well", *New Directions for Teaching and Learning*, No. 32. San Francisco: Jossey-Bass, 1987.

[3] D. Kember, D.Y.P. Leung, and K.P. Kwan, "Does the use of student feedback questionnaires improve the overall quality of teaching?", in *Assessment & Evaluation in Higher Education*, vol. 27, no. 5, pp 411-425, 2002.

[4] C.S. Galbraith, G.B. Merrill, and D.M. Kline, "Are student evaluations of teaching effectiveness valid for measuring student learning outcomes in business related classes?", A Neural Network and Bayesian analyses, in *Research in Higher Education*, vol. 53, pp 353-374, 2012.

[5] M. Alauddin and T. Kifle, "Does the evaluation of teaching instrument really measure instructors' teaching effectiveness? An econometric analysis of students' perceptions in economics courses", in *Economic Analysis and Policy*, vol. 44, pp 156-168, 2014.

[6] G.I. Nitin, V. Shankararaman, and S. Gottipati, "Analyzing Educational Comments for Topics and Sentiments: A Text Analytics Approach", in *Proc. of Frontiers in Education Conference 2015*, El Paso, Texas, pp 1658-1666, 2015.

[7] S. Gottipati, V. Shankararaman, and J.R. Lin, "Latent Dirichlet Allocation for textual student feedback analysis", in *Proc. of the 26th Int. Conf. on Computers in Education ICCE 2018*: Manila, Philippines, pp 220-227, 2018.

[8] V. Shankararaman, S. Gottipati, and J.R. Lin, "Extracting implicit suggestions from students' comments – A text analytics approach", in *Proc. of the 25th Int. Conf. on Computers in Education ICCE 2017*: Christchurch, New Zealand, pp 261-269, 2017.

[9] S. Gottipati, V. Shankararaman, and J.R. Lin, "Text analytics approach to extract course improvement suggestions from students' feedback", in *Research and Practice in Technology Enhanced Learning*, vol. 13, no. 6, pp 1-19, 2018.

[10] A.V.Y. Lee and S.C. Tan, "Promising ideas for collective advancement of communal knowledge using temporal analytics and cluster analysis", in *J. of Learning Analytics*, vol. 4, no. 3, pp76-101, 2017. http://dx.doi.org/10.18608/jla.2017.43.5

[11] N.M.M. Dowell, and A.C. Graesser, "Modelling learners' cognitive, affective, and social processes through language and discourse", in *J. of Learning Analytics*, vol. 1, no. 3, pp 183-186, 2014.

[12] A.F. Wise, Y. Zhao, and S.N. Hausknecht, "Learning analytics for online discussions: embedded and extracted approaches", in *J. of Learning Analytics*, vol. 1, no. 2, pp 47-71, 2014.

[13] Z. Sun, C-H. Lin, M. Wu, J. Zhou, and L. Luo, "A tale of two communication tools: Discussion-forum and mobile instant-messaging apps in collaborative learning", in *British Journal of Educational Technology*, vol. 29, no. 2, pp 248-261, 2017.

[14] A.Y.K. Chua and S. Banerjee, "So fast so good: an analysis of answer quality and answer speed in community question-answering sites", in *J. of American Society for Information Science and Technology*, vol. 64, no. 10, pp 2058-2068, 2013.

[15] R.K. Saha, A.K. Saha, and D.E. Perry, "Toward understanding the causes of unanswered questions in software information sites: a case study of Stack Overflow", *ESEC/FSE*, 2013 © ACM. doi: 10.1145/2491411.2494585

[16] S. Gottipati and J. Jiang, "Finding thoughtful comments from social media", in *Proc. of COLING 2012: Technical Papers*, Mumbai, pp 995–1010, 2012.

[17] M.L.F. Cheong, J. Y-C. Chen, and B.T. Dai, "Integrated Telegram and web-based forum with automatic assessment of questions and answers for collaborative learning", in *Proc. of IEEE Int. Conf. on Teaching, Assessment and Learning for Engineering TALE 2018*, Dec 4—7, Wollongong, Australia. https://doi.org/10.1109/TALE.2018.8615137

[18] M.L.F. Cheong, J. Y-C. Chen, and B.T. Dai, "An intelligent platform with automatic assessment and engagement features for active online discussions", *Advances and Trends in Artificial Intelligence: 32nd Int. Conf. on Industrial, Engineering and Other Applications of Applied Intelligent Systems, IEA/AIE 2019*, Graz, Austria, July 9-11, Proceedings. 11606, pp 730-743, 2019.

[19] T-Y. Leong and M.L.F. Cheong, *Business Modeling with Spreadsheets: Problems, Principles and Practice*, Singapore: McGraw-Hill, 2015. http://worldcat.org/isbn/978981459

[20] E. Hoque and G. Carenini, "Interactive topic modeling for exploring asynchronous online conversations: design and evaluation of ConVisIT", *ACM Trans. on Interactive Intelligent Systems*, vol. 6, no.1, article 7, 2016. http://dx.doi.org/10.1145/2854158