Piloting Learning Analytics to Support Differentiated Learning through LearningANTS

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ABSTRACT: Students at Singapore Polytechnic (SP) have diverse mathematical aptitude. Academically-weak students need much hand-holding while academically-strong students may get bored if not inspired. It remains a challenge for any teacher to meet individual student's learning needs. SP piloted LearningANTS, a learning analytics system that supports differentiated learning, in a mathematics module in semester one of the 2016-17 academic year. Research at SP demonstrates that differentiated learning was supported and students using LearningANTS performed better when compared to those in traditional tutorial settings. Learning points gathered will be used to fine-tune the system for the next deployment which will benefit about 1,500 students.

Keywords: learning analytics, differentiated learning, teaching and learning

1 DEPLOYMENT

LearningANTS, a learning analytics system that supports differentiated learning, was deployed to replace the traditional tutorial in a bridging mathematics module. Students were encouraged to log into the system to practise online tutorial questions whenever each topic was covered in lecture, and use the

system during tutorial for learning. The system diagnoses students' learning and recommends individualised learning schedules. Teachers are able to monitor both class' and individual students' performances to offer more effective help.

2 MOTIVATION

The School of Mathematics and Science at Singapore Polytechnic (SP) offers mathematics to all students in the institution. One of the challenges teachers face is to meet the diverse learning needs of students who come with varied mathematics aptitudes. On the one hand, we have students whose foundation in mathematics is very weak – some may not have taken any mathematics for two years prior to joining SP even if they enrolled in SP to pursue an engineering diploma[12] which requires good grounding in mathematics. On the other hand, we see mathematically strong students who are ever so ready to embark on advanced mathematics when they join the institution.

Our research question for this study: Could learning analytics support differentiated learning, and thus improve teaching and learning?

3 APPROACH

"Differentiated learning or instruction is a philosophy for effective teaching that involves providing students with different avenues to acquiring content; and to developing teaching materials and assessment measures so that all students within a classroom can learn effectively, regardless of differences in ability". (Tomlinson, 2001)

Halls (2002) explains that differentiated instruction facilitates the approach to "teaching and learning for students of differentiating abilities in the same class. The intent is to maximise each student's growth and individual success by meeting each student where he or she is… rather than expecting students to modify themselves for the curriculum."

While differentiated learning could be applied in terms of Content (what students learn), Process (how students learn) and Product (the end result of student learning), LearningANTS focused on differentiation in Content.

[12] Diplomas are 3-year post-secondary programmes offered by polytechnics in Singapore with the aim of training professionals to support the technological and economic development of Singapore. Polytechnic graduates could either join the industry or further their studies in a university upon graduation. For more information, refer to https://www.moe.gov.sg/education/post-secondary#universities

LearningANTS[13] is the product of a research collaboration between SP and its industry partner 3ELogic. The system was designed to leverage analytics to support differentiated learning. LearningANTS was deployed in a bridging mathematics module in semester one of the 2016-17 academic year where about 300 students were registered in the module. This bridging mathematics module is predominantly taken by students who are weak in mathematics, many of which may not have taken any mathematics for two years prior to enrolling at SP.

To study how LearningANTS supports differentiated learning, control and experimental groups were set up to compare the effectiveness of the system against traditional tutorials in the module. Immediately after lectures were delivered, a pre-test was administered. While the control group then continued with a traditional tutorial, the experimental group used LearningANTS as their tutorial. A post-test was then administered at the end of the semester.

For the experimental group using LearningANTS, learning topics were adaptively released to students based on a teacher-defined teaching plan. There were altogether up to four difficulty levels of learning achievement in LearningANTS – Beginner, Advanced Beginner, Competent, and Expert for each topic. Students' progression through the difficulty levels for each topic were dependent on their own ability. LearningANTS diagnosed students' learning and generated individualised learning schedules for each student following the teacher-defined learning plan.

Data collected of students' learning is automatically tracked and presented in a simple way to help students monitor their own learning. Students could review all the questions that they have attempted, and communicate with their teachers via a feedback feature in the system if they needed help with the questions. At the same time, teachers could monitor the learning progress of their class through the system. This facilitated the face-to-face tutorial sessions as teachers could then offer more targeted help to the class, for example, by going over questions with which a majority of the students had trouble, as well as diving down to help an individual student who was struggling to progress in the system.

4 FINDINGS

When the system was deployed during the pilot to the experimental group, we saw a utilization rate of 93.8%, or 153 students out of a total of 163 students who were invited to use the system. For the students who used the system, the system diagnosed and recommended additional learning topics to 111 students. This additional recommended learning corresponded to 437 lessons covering 20 different topics. Students attempted and leveled up at least one difficulty level for 98% of the 437 recommended lessons.

[13] The research on LearningANTS was funded under the Public-Private Co-Innovation Partnership funding scheme from October 2014 – Apr 2015, and October 2015 - present. Many features in LearningANTS were shaped by the findings of an empathy study that had been carried out with targeted users before system development.

We compared the average improvement between pre- and post-test for both the experimental group (153 students) and the control group (138 students) by setting up a hypothesis test (two-sample t-test) as follows:

$$H_0 : \mu_{Experimental\ group} - \mu_{Control\ group} = 0$$
$$H_1 : \mu_{Experimental\ group} - \mu_{Control\ group} > 0$$

Table 1: Comparison of results between experimental and control groups.

	Experimental	*Control*
Mean	7.58496732	4.579710145
Variance	155.8348383	134.3038189
Observations	153	138
Hypothesized Mean Difference	0	
df	289	
t Stat	2.1294372	
P(T<=t) one-tail	0.017031597	
t Critical one-tail	1.650143229	
P(T<=t) two-tail	0.034063193	
t Critical two-tail	1.968206436	

As shown in Table 1 above, the p-value of the test at 1.7% is less than 5% ($p < 0.05$), so we rejected the null hypothesis. Hence, there is significant evidence to suggest that the mean mark of the experimental group is more than the mean mark of the control group.

5 BENEFITS AND CHALLENGES

The benefits of learning analytics are manifold. With learning data automatically tracked, data can be visualised and analysed to gain insights into students' performance. In LearningANTS, this can be carried out at the class-, student-, topic-, concept-, and even question-level.

When the study was conducted, teachers were able to identify struggling students quickly. It was found that a good 25% of the students could not clear even the Beginner level. And only 40% achieved Advanced Beginner level or higher. Because solutions were provided for each question and Beginner level questions were supposedly simple, the fact that 25% attempted the questions but could not clear this level was surprising. It suggested that students not only lacked understanding of pre-requisite concepts identified by the system, teachers also learned that students had difficulty in understanding the step-by-step solutions provided in the system which teachers had initially thought were good enough and clear. This insight certainly narrowed down the areas in the module that needed to be further enhanced to better support the mathematically weaker students.

A good 7% of students achieved at least Competent level. Students who were mathematically more advanced did not have to be slowed down by their classmates in learning. They were able to self-regulate their own learning and progress to attempt more challenging questions to stretch their understanding of the topics. Expert level questions remained difficult for students. To address this steep learning curve, scaffolds such as hints could be added to the questions in the future.

Despite the benefits and affordances of learning analytics, some teachers found it a challenge to adopt learning analytics. One challenge shared was the lack of time due to a tight curriculum that prevented teachers from fully embracing learning analytics. To mitigate this challenge, we feel it is important to integrate learning analytics into the teaching and learning process. When it is part of the process, then the adoption will come naturally.

Another challenge surfaced was the lack of guidance in using analytics. For teachers new to analytics, training will need to be provided. Moving forward, the team will look at use cases to guide teachers more prescriptively on how learning analytics can be adopted to improve teaching and learning both within and without the classroom.

6 CONCLUSION

Through this study, we saw how learning analytics supported differentiated learning. Both students and teachers were able to leverage data to better monitor students' learning. From the data gathered, insights could be gained to further enhance module delivery as well as the design of LearningANTS to better support teaching and learning. Lessons learned from the study will fine-tune future roll-outs of the system to facilitate learning analytics and differentiated learning.

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