ENHANCING PASTORAL CARE AND ACADEMIC MONITORING EFFORTS USING THE AiE-PFP LEARNING ANALYTICS SOLUTIONS

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Abstract

This paper describes the journey undertaken by a 5-polytechnic project team in collaboration with an external vendor in Singapore to produce 2 learning analytics (LA) solutions in education, a predictive model and a personal tutor facing dashboard. The predictive model generates projected learning needs of students by running machine learning and statistical rule-based algorithms through data such as attendance rates and past academic performance. The dashboard then displays the projected student learning needs as well as other pertinent information about the students such as choice order of diploma, academic performance progress, participation in co-curricular activities (CCAs), and other behavioural indicators. The intent of the LA solutions is for personal tutors (lecturers who take care of pastoral care and academic needs of students) to be able to glean insights and devise and apply appropriate interventions based on the data presented. With better support and interventions, it is hoped that student academic outcomes will be optimised.

After the 1-year pilot which involved 104 personal tutors of 5 polytechnics, a comprehensive evaluation exercise was conducted amongst the students and personal tutors to ascertain the effectiveness of the LA solutions. Reception amongst both students and personal tutors was generally positive. Personal tutors found the LA solutions to be helpful in getting to know their tutees better and identifying areas that require support. Students perceived that their personal tutors had provided them with sufficient pastoral care and guidance. A task analysis exercise that measured time spent before and after using the LA solutions also revealed that, after the implementation of the dashboard, personal tutors can save time not having to consolidate data from disparate sources on their own accord.

The successful pilot led to a second phase of the project, which is to implement similar LA solutions to other diploma courses.

Keywords: *learning analytics, predictive model, dashboard, personal tutors, student learning needs, interventions*

Introduction

In recent years, there has been growing interest amongst institutes of higher learning (IHLs) to adopt learning analytics solutions to enhance student learning experience. Due to this interest, the 5 polytechnics in Singapore undertook a project to explore the use of learning analytics in education in 2019. 2 learning analytics (LA) solutions resulted from the project - a predictive model (PM) that produces projected student learning needs and a personal tutor (PT) facing learner profile dashboard (LPD). In this paper, we will start by describing the development and implementation process of the LPD and PM. The authentic use of the solutions by a PT to support her tutees is elaborated before we present evaluation outcomes. Future work will also be discussed.

Method

Polytechnic Foundation Program (PFP) is a 1-year bridging program for outstanding Normal Academic stream graduates to be admitted into polytechnic diploma courses, without taking O level examinations. In this program, students take modules that are prescribed by Singapore's Ministry of Education (MOE), such as English and Mathematics, and domain-specific modules such as IT, Chemistry and Business. PFP students must pass all modules before they can advance to their chosen diploma courses.

The LPD and the PM were developed with the PFP PTs in mind. Each PT is assigned a class of about 20 PFP students as tutees and they are tasked to guide and mentor their tutees throughout the PFP year, in academic and non-academic aspects. Hence, it is essential that the PTs are well-supported in their role with data and analytics tools, in order that they can do their job well.

Guided by the principle that LA solutions should focus on problem statements and needs of the users, (Michos, Lang, Hernandez-Leo & Price-Dennis, 2020; Demmans Epp, Perez, Phirangee, Hewitt & Toope, 2019) who are the PTs in this case, the project regularly consulted the PFP team on problems they commonly encounter while running the program. The LA solutions were then developed to address those problems. Subsequently, iterative discussions were held with the users to refine the solutions throughout the development process. This user-centric approach aimed to improve

usage and adoption of the solutions (Denmans Epp et al., 2019; van Deen et al., 2019; Daley et al., 2020).

The LPD and PM were developed to answer the following problem statements (PS) of PFP PTs.

PS1: What is the socio-economic and academic background of my individual students?

PS2: Individually, who are likely to be in the A, I or E group at the end of PFP year and why?

PS3: How do the various groups of students (A, I or E) progress academically throughout the PFP year?

In the problem statements above, the "A" group refers to PFP students who perform at the top of the cohort, the "E" group refers to those who perform at the bottom and the "I" group includes all the rest.

A 5-polytechnic project team was formed to work with a vendor to produce the LA solutions. The project team comprised of representatives from functional, pedagogical and technical areas. The team members worked closely with the vendor in various aspects of the project such as requirements gathering, data assessment, design and development as well as user testing.

Predictive Model (PM)

Historical data from the last 7 PFP cohorts were used to train the model. To ensure sufficient accuracy of the model, the *k*-fold cross-validation method was carried out because it is widely used when data is limited (Dantas, 2020; Brownlee, 2020). 4 models were developed to predict outcomes of PFP students, in Science & Technology and non-Science & Technology tracks, using pre-polytechnic as well as in-polytechnic data, at the beginning of each of the 4 PFP terms. The models that were ultimately assessed to be most accurate for adoption were logistic regression models that use student data such as pre-polytechnic N level results, in-polytechnic attendance rates, academic performance consistencies and key subject results as predictors.

Learner Profile Dashboard (LPD)

In building the dashboard, the functional representatives from all 5 polytechnics regularly gave their inputs in areas such as data attribute requirements, visualization designs and placements and interactivity of dashboard. An expert dashboard designer was also involved to give recommendations on best practices of dashboard design. This helped to smoothen and expedite the development process.

The LPD comprises of 4 pages, namely the Student Performance (SP), Individual Student (IS), Individual Student Performance (ISP) and At-risk Students (AR), which are interactive with drill-through from one page to the next. It consolidates and displays rich information on student profiles using data from disparate sources such as student administrative system, file uploads, learning management system as well as projected student needs via the PM. Controls were also built in to ensure proper role-based data access, as this is a requirement of Model AI Governance Framework (World Economic Forum, 2020).

Implementation

In April 2021, the LA solutions were rolled out to all 104 PFP PTs of the 5 polytechnics. Users had to be adequately trained to ensure they utilize the LA solutions in a manner that abides by the Model AI Governance Framework. Before the term started, the PTs attended a hands-on training session to learn how to navigate the dashboard, interpret the data and handle the data responsibly. They discussed how they could use the insights from the LA solutions to devise appropriate interventions. Halfway through the term, another training was conducted to enhance their understanding of how the PM works. The PTs were briefed on the algorithm that drives the model, how to interpret accuracy statistics of the model and propensity scores, and the explainability of the PM. This knowledge is necessary as the LA solutions were designed to involve "human-in-the-loop" whereby user interpretation and decision-making play a vital role. At various milestones of the PFP year, the PTs were prompted to use the LA solutions as needs arose. Instances of such milestones include Meet-the-Parent session at mid-year and individual student counselling after major assessments. Besides formal trainings, PTs were frequently engaged in dialogues and communications that enhanced their awareness of institutional and personal benefits that the LA solutions offer. It is desired that such engagement will motivate some of them to become LA champions in future (Ferguson & Clow, 2017).

The Learning Analytics Solutions

The 4 pages of the LPD can be seen in Figure 1 below.

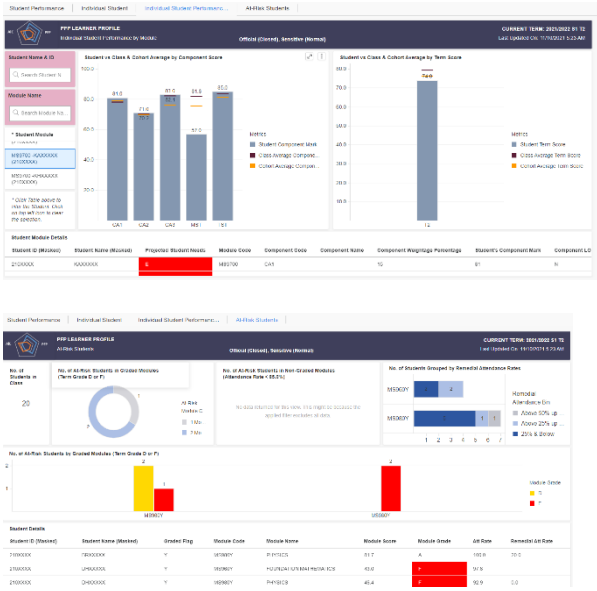

Figure 1. PFP LPD comprising of 4 pages: (First) *SP* page; (Second) *IS* page; (Third) *ISP* page; (Last) *AR* page

SP page: This page provides student details at the class level such as socio-economic and academic background. It also displays PM results, allowing the PTs to identify students who need different levels of support. This page is useful for PTs to get to know the class better and offer early support and assistance at the beginning of PFP. This addresses PS1 and PS2.

IS page: This page provides information at the student level such as academic performance and attendance for all the modules taken in the term. This page is useful for PT to drill down to a particular student to monitor his/her performance for each module and compare that to the class and cohort. PTs can then provide counselling to students who are struggling academically on how to better manage their time and optimize their learning strategy to improve their academic performance. This addresses PS2 and PS3.

ISP page: This page provides information at the individual student-module level. PTs can view each student's academic performance in every assessment component of each module. In instances where student performed inconsistently across different assessment components, PT stepped in to address the issue in a timely manner, for instance by offering advice on how to handle examination jitters. This addresses PS2 and PS3.

AR page: This page serves as a diagnostic tool for PTs to conduct counselling to poor-performing students. It highlights to PTs information such as number of modules that students are doing badly at, students who are missing lessons and remedial lessons. This addresses PS2 and PS3.

A PT's Use Cases

The following sections will elaborate about how one PT, Diana, utilised the LA solutions. Diana has more than 10 years of teaching experience but is relatively new to the role of PT.

At the start of PFP, Diana used *SP* page before meeting her tutees. From the dashboard, she was able to tell the following.

i. The class was of average academic ability as the average N level raw score was 8.6 (raw score is between 5 and 12, with 5 being the best and 12 being the worst score). Diana decided to adopt a medium-paced teaching speed.
ii. There were 6 tutees in the class who were projected to be in the "E" group. Diana would want to closely monitor these 6. She held one-to-one conversations with them to establish rapport and offer support early in the term.
iii. There were 3 tutees with declared Special Education Needs (SEN). Diana checked-in with them if they wanted to request for special learning support such as time extension during major assessments.
iv. 8 students did not take Additional Math in secondary school. They might struggle in PFP math module and since Diana was their math lecturer, she offered remedial sessions to them.
v. 1 student was offered his 5th choice of diploma. As a result, the student may not be motivated to work hard in his studies. Diana kept a closer watch and provided education and career counselling to the student regularly.
vi. Based on the per capita income (PCI), 9 students could benefit from financial support. Diana offered them bursary or laptop subsidy applications as assistance.

During the terms, Diana used the LPD to monitor the overall attendance and academic progress of her tutees in individual modules. Such information allowed her to check-in with tutees, as well as module lecturers, when potential issues were detected.

The LPD provided information about the tutees without Diana having to scroll through one student at a time via the student administration system. In one glance, Diana was able to gauge the academic and background profile of her class as well as monitor them as the term progressed. She could then decide on the appropriate teaching and pastoral care approaches early on. As she became more aquainted with the tutees, she could then adjust her approaches to suit their needs. She could also identify the modules that her tutees were struggling in and worked with the module lecturers accordingly.

Use case 1: "Struggling Sarah"

Sarah was admitted into PFP with a decent N level aggregate score of 7. She was offered her first choice of diploma and was predicted by the PM as "I" student at the beginning of the program. Based on her background information, she would have been expected to succeed in the program. As the term progressed, however, Diana noticed, from the *IS* page (Figure 2), that Sarah was not attending lessons regularly, particularly for one module. Diana contacted the module lecturer to find out more about the situation. She then counselled Sarah and highlighted repercussions of low attendance. She also sent reminders to Sarah to attend class, especially those that started early in the day.

The module lecturer also monitored Sarah and provided regular feedback to Diana on Sarah's progress in the module.

Despite all the efforts, at the end of Term 1, the *IS* page (Figure 2) showed that Sarah was performing badly in many modules. She failed 3 modules and scored significantly below cohort and class averages in others. Diana arranged to meet Sarah's parents to inform them of Sarah's academic performance and to discuss interventions to help her. Diana also found out from her conversations with Sarah that she was facing anxiety and motivational issues that prevented her from putting in her best efforts in her studies. Sarah was thus referred to the polytechnic counsellor to help her cope with her anxiety issues. She was also assigned for remedial lessons for the modules that she was not performing well. Diana hoped that the holistic approach would help Sarah.

Eventually, Sarah managed to complete PFP although her academic outcomes were below average.

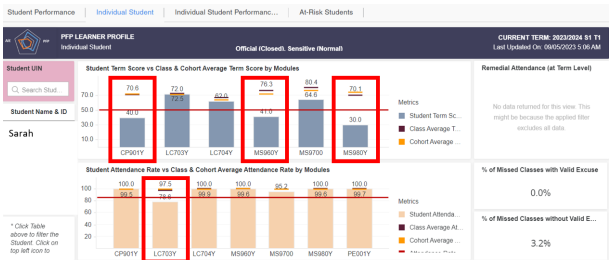

Figure 2. Sarah's low module attendance and poor module performances as flagged out by *IS* page

Use case 2: "Declining Dave"

Dave had been an outstanding student throughout the first 3 terms of PFP. He entered PFP with a score of 9 and was posted to his second diploma choice but had been attending class regularly and doing well in his past assessments in all modules. In fact, he was doing so well that the PM projected him to be "A" student in terms 2 and 3, an improvement from the initial "I" projection in term 1. He was also a responsible class representative.

Diana was thus surprised that in the beginning of term 4, Dave was projected as "I" student, a decline from term 3 (Figure 3). From the *IS* page (Figure 4), she realised that Dave was doing well in modules such as Math, Physics and Applied Science, but not as well in language modules. When she drilled into the component assessment scores of the module through the *ISP* page (Figure 5), it appeared that Dave was struggling with report writing assignments of the module.

Diana arranged a chat session with Dave to find out more. She started by commending him on being an excellent class representative and on doing well in his Math, Physics and Applied Science modules. She then queried on his poorer performance in language modules. Dave's responded that he found it challenging to do report writing as he had always struggled with English. He highlighted that he had scored a B3 for English at N levels, which is the poorest possible grade for English to be eligible for PFP. Diana encouraged Dave to check with the module lecturer on ways to enhance his report writing skills. She also encouraged him to search for online resources to learn how to write better reports. Dave was receptive to these suggestions and promised to put in effort to improve.

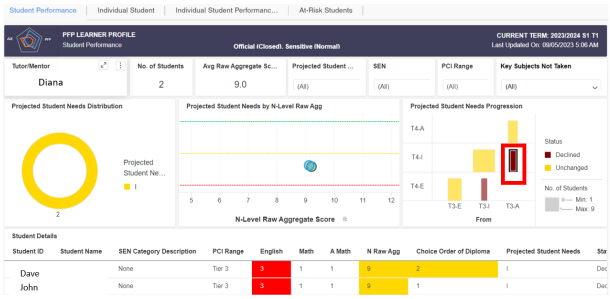

Figure 3. Dave's projected student needs went from "A" in Term 3 to "I" in Term 4 as seen on *SP* page

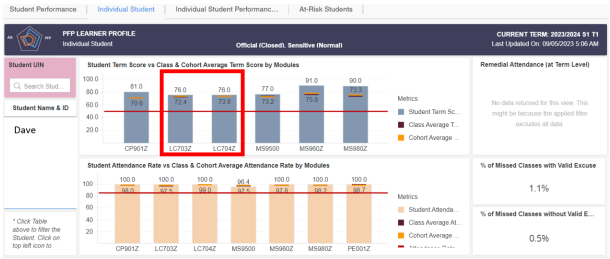

Figure 4. From *IS* page: Dave's performance in language modules was not as good as that in other modules

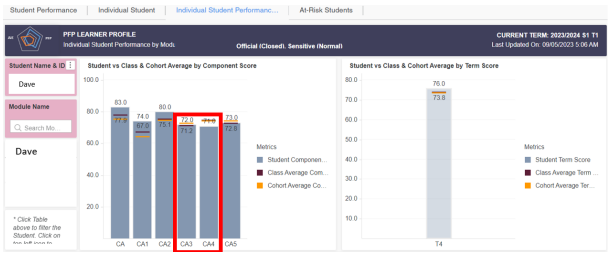

Figure 5. From *ISP* page: Dave scored below class and cohort averages in writing assessment components

The 2 use cases showcase the usefulness of the LPD in identifying struggling students as well as students who could be nudged towards greater achievements. In the case of Dave, previously, without LPD, Diana will not have noticed that decline in performance as readily. Often, timeliness of appropriate interventions is essential to optimise the learning outcomes of students. With the LPD, PTs can intervene more effectively and efficiently.

Findings

To evaluate the project holistically, various evaluation methods were adopted to capture feedback and opinions of the PTs and the students.

Staff Survey

The *Technology Acceptance Model (TAM) Survey* was administered to all PTs who participated in the project.

TAM, developed by Davis (1989), is a widely used model to explain usage and acceptance of technology and information systems by individual users. Feedback was collected on PTs' experience in the following 6 aspects:

i. *Perceived Usefulness* indicates the extent of the user's belief that using a specific system would enhance his or her job performance. More than 87% of respondents agreed that using the LPD would enhance his or her job performance in all 6 questions.
ii. *Perceived Ease of Use* indicates the extent of the user's expectation that using a specific system would be free of mental and physical efforts. More than 81% of respondents agreed that using the LPD would be a relatively effortless affair in 3 out of 5 questions.
iii. *Trust* defines the confidence placed by the user on the system and forms the disposition towards the use of AI-assisted technologies. More than 93% of respondents trusted the LPD in all 3 questions.
iv. *Anxiety* defines the extent of the user's fear or apprehension, when exposed with the possibility of using a system. More than 81% of respondents did not feel apprehensive when using the LPD in all 3 questions.
v. *Relative Advantage* reflects the user's perception of the benefits of using a specific system in comparison with other existing alternatives. More than 81% of respondents agreed that using the LPD is better than using existing data systems in all 6 questions.
vi. *Behavioral Intention to Use* is the extent of the user's intention to perform or not perform some specified future actions. More than 87% of respondents agreed that they intend to use and will recommend others to use the LPD in 2 out of 3 questions.

The responses were very positive and a summary of the survey results from the 26 questions is shown in Table 1 below.

Table 1: TAM Survey Outcomes

Responses	Perceived Usefulness	Perceived Ease of Use	Trust	Anxiety (Negative Construct)	Relative Advantage	Behavioral Intention to Use
Strongly Agree / Agree / Somewhat Agree	91.67%	81.25%	95.83%	18.75%	91.67%	83.33%
Strongly Disagree / Disagree / Somewhat Disagree	8.33%	18.75%	4.17%	81.25%	8.33%	16.67%

Task Analysis

The intent of conducting *Task Analysis* is to offer a measurement of the possible time savings arising from the LA solutions implementation. 2 PTs and 1 Course Chair participated in the task analysis. Based on guiding use cases, they completed a set of 20 contextualized tasks before and post implementation of the LPD. The following were logged during the analysis for both pre and post task analysis sessions:

i. No. of tasks that can be completed by the participants
ii. Time taken to complete those tasks
iii. Systems used to obtain the required information

The findings from the task analysis suggested that there is time savings of about 281 hours per academic year. It also proved that, with the LPD, PTs and Course Chair can complete all the information gathering tasks independently instead of using multiple systems or requesting for assistance from other colleagues. The aggregation of relevant information in LPD helps to streamline processes and improve work efficiency.

Focus Group Discussions

All the PTs involved in using the LPD were invited to attend 4 focus group discussions (once per term) to solicit their feedback on user experience. During the discussions, the LPD was evaluated in the areas of implementation issues, ease of usage, actionable insights and student outcomes. Generally, all users felt that the dashboard is useful and provides them with additional insights of the students. There was also sharing of good practices and narratives of how users were making use of the dashboard to devise interventions.

The findings from the discussions were aligned with the *TAM* survey results:

i. *Perceived Usefulness* (91.67%): From the various sharing of how different PTs utilized data from the LPD for interventions such as recommendation for remedial lessons, individual counselling with different focuses based on different student profiles, we can infer that PTs find the dashboard useful.
ii. *Perceived Ease of Use* (81.25%): Perception of usability improved over time when the PTs gradually got used to the dashboard. They have also shared challenges and provided recommendations to improve ease of use. One suggestion was to pace out the training content into bite-sized chunks to enable better learning of navigation of dashboard.
iii. *Trust* (95.83%): From the sharing of how PTs use information from LPD to prepare their dialogues with various stakeholders, it can be inferred that PTs trust the data. PTs also trust LPD enough to use it as a diagnostic tool to plan intervention actions.
iv. *Relative Advantage* (91.67%): It is evident that PTs prefer using LPD over their existing processes as they commented on how they are now able to access all the important data without having to log into separate systems. The amount of time saved is a huge benefit afforded by the dashboard.
v. *Behavioral Intention to Use* (83.33%): When asked how they can be motivated to use the dashboard more, some PTs requested for more functionalities and data such as alerts to at-risk behaviors and LMS data. They commented that as the terms progressed, their usage declined as they have built sufficient understanding of their students. As such, most of them will recommend the dashboard to other users, but to encourage higher frequency of use, more dynamic data will have to be included.

All of the PTs agreed that the teacher (human-in-the-loop) is critical in using the solutions. PTs primarily used the dashboard as a reference to confirm teacher's own observations of the tutees before carrying out interventions.

"As a PT, I have pastoral practice with my students called Heart-to-heart-talk (H2HT) every 2-3 weeks.

I will meet different students on different days, depending on their breaks.
I use this dashboard to understand my students' backgrounds to kickstart h2ht. Previously the H2HT is more generic which we talk about how are they settling in and students usually say they are ok. But now, with the dashboard, I can jump straight into using PCI to talk about financial help. And from there I was able to suss out one student whose parents lost their jobs and as they have zero income. I followed up by asking him how he feels. This really opens up conversations. Previously happen after term 1 due to lack of pre-poly data. But now able to bring it forward to first few weeks of Term 1."

Student Perception Survey

PFP students were polled on whether they feel that they have been adequately supported by their PTs with 8 quantitative questions (Myint, S. K., 2001). On average, 79% of the PFP students gave positive ratings (Table 2). This indicated that the students acknowledged the great care and support offered by their PTs. It also affirmed the PTs' narratives during the focus group discussions that they had used LPD to better support their tutees.

Table 2: Student perception survey outcomes

Question	Average Rating (out of 5 points)	Positive Rating
Q1 The personal tutor cares for my well-being	4.34	83.3%
Q2 The personal tutor cares for my learning	4.44	89.6%
Q3 The personal tutor goes out of his/her way to help me	4.23	79.4%
Q4 The personal tutor considers my feelings	4.26	81.5%
Q5 The personal tutor helps me when I have trouble with the work	4.35	84.0%
Q6 The personal tutor talks with me	4.08	71.8%
Q7 The personal tutor is interested in my problems	3.86	62.4%
Q8 The personal tutor's questions help me to understand	4.21	79.4%

Results and Future Work

The reception to the LA solutions was promising and the pilot proved to be a successful one. The team continued to refine the LPD by incorporating easily accessible user guides and intervention suggestions. Another module lecturer dashboard was also developed using dashboard templates.

This pilot has provided a glimpse of an exciting analytics and data journey for educators in the future. The vision is that all lecturers will be armed with meaningful data and analytics tools that allow them to execute teaching and learning decision making in a data-informed manner. Plans are underway to roll out similar LA solutions to other diploma courses in the 5 polytechnics.

Acknowledgements

The authors would like to thank the following for their contributions to this paper.

1. Singapore Polytechnic's (SP) EDU team
2. PFP PTs of AY2021/2022
3. SP's AiE project team
4. Management of SP's School of Mathematics and Science

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