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Empowering Student Teachers' Learning with Personalised Adaptive Learning and Assessment System (PALAS): The NIE-NTU, Singapore Experience

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Abstract*— This paper discusses how adaptive technology is harnessed to support the teaching and learning of affixes in the Malay grammar. Personalised learning has gained significant traction in recent years as the demand for individualised education increases and advanced technologies such as Artificial Intelligence (AI) emerge. AI powered adaptive technology has the potential to enhance the effectiveness of personalised learning by providing real-time feedback and customised learning experiences. Therefore, the Personalised Adaptive Learning and Assessment System (PALAS), an AI-enabled learner-centric platform, is created to support the learning of Malay Morphology modules for student teachers at National Institute of Education (NIE), Nanyang Technological University (NTU), Singapore. PALAS endeavours to provide each learner with a personalised learning experience that aligns with their learning path. Encouraging findings such as learning gains, users' motivation to learn, understanding of the grammar topic and confidence in teaching the Malay Language, have emerged from the study. The author will be sharing on the various aspects of adaptive learning affordances in PALAS that support these outcomes such as curriculum mapping, learning loops, diagnostic and mastery levels.

Index Terms*— personalised learning, adaptive learning, Malay grammar, artificial intelligence, higher education.

I. INTRODUCTION

Learning grammar is crucial for effective communication, especially if the learners are student teachers teaching grammar to students in schools. The student teachers are expected to know the grammar rules and structures well. This is to ensure clarity and precision in both written and spoken language to be the role model to their students in schools. In addition, language teachers are expected to have mastered grammar skills to enable them to impart grammar knowledge to their students. Considering this, we have developed the **P**ersonalised **A**daptive **L**earning and **A**ssessment **S**ystem (**PALAS**) to harness its adaptivity affordances in teaching and empowering the learning of the Malay language grammar.

II. RESEARCH PURPOSE AND DESIGN

A. Purpose and Objective

PALAS is a proof-of-concept. To do so, we have developed an AI-enabled personalised adaptive learning and assessment system that we can pilot on the Malay Morphology module at Asian Languages and Cultures Academic Group, NIE-NTU, Singapore. PALAS is a learner-centric platform that provides each learner with an individualised learning experience, allowing them to progress along their unique learning path. We evaluate the effectiveness of the learning experience provided by PALAS from the pilot classes through learning analytics data, questionnaires, and pre-test and post-test. We designed PALAS as a single sign-on (SSO) via Blackboard, a learning management system at Nanyang Technological University (NTU), Singapore. From this experience, we hope to be able to build our adaptive learning system in NTULearn/Blackboard and expand its adoption to more courses and languages.

B. Research Design and Method

This research project comprised two phases: Pilot 1 and Pilot 2. The design thinking approach was taken into consideration during the development of both Pilot 1 and Pilot 2. Design thinking basically foregrounds the notion that creating and testing iteratively will provide continuous learning and improvement of the initial ideas [20]. Additionally, design thinking is deeply human-centred and consists of three overlapping spaces: inspiration, ideation, and implementation [3].

The student teachers reading the Malay Morphology come from three programmes: Diploma in Education, Bachelor of Arts in Malay Studies and Education, and Postgraduate

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Diploma in Education. The inspiration space shows that these student teachers have different mastery levels of Malay grammar. This is because some students attended Malay Language lessons at secondary, junior college, and university levels, depending on their academic qualifications. However, providing each student teacher with individualised or customised instructions is nearly impossible due to energy and time constraints. As such, there is a need to support them with a system that could help them to learn at their own time, pace, phase, and place. In addition, adaptive technology provides customised programme adjustments based on individual student's level of demonstrated mastery [20]. Moreover, it enables personalisation of instructions to improve or accelerate a student's performance [12]. By adopting the adaptive technology, as the instructor, my teaching time could be freed up for more in-depth discussions of other grammar topics. For this proof-of-concept research, we focus on the topic of affixes with the intention to expand PALAS with other topics in morphology and syntax (Fig. 1).

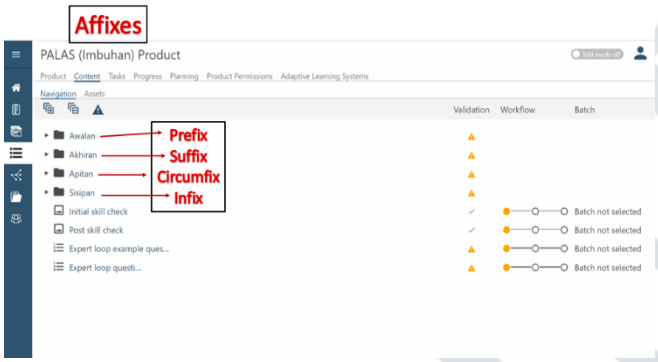

Fig. 1 Malay Grammar Affixes

Within the ideation space, two developments took place - resources and portal. The resources were developed according to the curriculum map that we created based on the Malay Grammar module. For affixes, the four affixes – prefix, suffix, circumfix, infix – were further expanded to its sub-topics. There are a total of 16 sub-topics (Fig. 2). For each sub-topics, questions were developed according to three different difficulty levels – easy, medium, hard. These resources support the learning design of PALAS. Besides the questions, instructional resources were also developed.

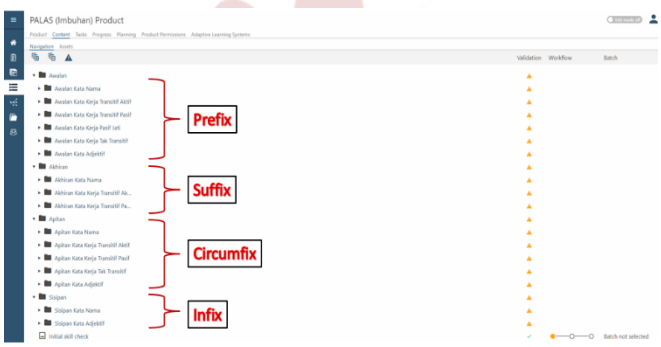

Fig. 2 Sub-Topics in PALAS

Concurrently, within this ideation space, the design and development of PALAS was taking place. Although PALAS resides in a web-based portal, it provides a seamless learning experience through SSO via Blackboard (Fig. 3). During the scanning in the inspiration space, there were several features that were found useful such as (a) initial skills check, (b) post skills check; (c) timely feedback; and (d) learning analytic report. In addition, references from other adaptive learning portal (Suryani, 2018) were taken into consideration when designing the user interface (UI) to ensure good user experience (UX) that is not only able to meet research objectives, but also able to engage and motivate the user.

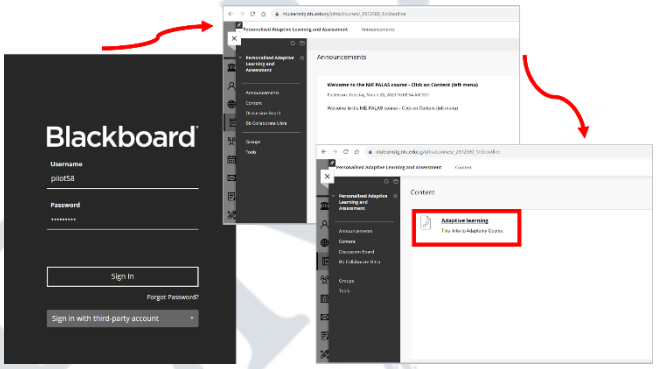

Fig. 3 SSO via Blackboard

Within the implementation space, Pilot 1 was conducted in March 2023 during the e-learning week. We reviewed the findings and made improvements before implementing Pilot 2 in October 2023. There are a total of 44 users and 53 users in Pilot 1 and 2 respectively.

C. Literature Review

Emerging adaptive learning technologies and data related to real-time assessments have captured the attention of higher education administrators. Ninety-two per cent of surveyed chief academic officers believe it could improve student learning outcomes [6]. In a survey, these leaders indicated that they viewed intelligent adaptive learning technologies as the most promising initiatives for improving the quality of student learning. These results were first reported in early 2016, and colleges and universities continue to incorporate adaptive learning technologies and given financial and faculty support.

According to Waters (2014), adaptive learning is an approach to instruction and remediation that uses technology and accumulated data to provide customised programme adjustments based on an individual student's level of demonstrated mastery [20]. Additionally, adaptive learning dynamically adjusts the level or types of instruction based on individual student abilities or preferences and helps personalise instruction to improve or accelerate a student's performance [12].

Personalised adaptive learning is learner-centred pedagogy, which emphasises that the pace of learning and the instructional approach should be optimised for the needs of

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each learner (U.S. Department of Education, Office of Educational Technology 2017). The adaptive learning approach utilises learning algorithms that provide real-time updates about the progress and respond with the necessary tools and actions to improve student learning [6].

The recent rise of big data technology gives way to the emergence of personalised adaptive learning and assessment systems due to their ability to record and interpret learner's characteristics and real-time interaction [16].

The algorithms built-in process the assessment data, interaction data, and learning behaviour data for each learner to create content, activities, feedback, scaffolding, and continuous assessment and other aspects of the course are adapted and personalised to the real-time context of the individual learner [24].

The delivery of customised learning via a personalised adaptive learning and assessment system involves three key activities [24] such as (a) initial assessment of prior knowledge directs the delivery of content, (b) scaffolding approach that addresses the learner's needs with continuous assessments and real-time feedback, and (c) learning data is constantly fed into the adaptive learning model which allows for the development of an individualised learning pathway for each student and refining relationships between learning objects and concepts.

In addition to using learners' data to determine the learning paths, the adaptive model also provides instructors with the learner data to track student progress, identify problem areas, and intervene [15][24]. Most personalised adaptive learning and assessment systems also provide learners with a dashboard to better understand their progress and roadblocks [15].

With regard to learner effectiveness, there have been several corporate-academic partnerships in adaptive learning in the past years that have successfully implemented personalised adaptive learning and assessment. The significant findings include time-to-learn reduction, closing achievement and engagement gaps, and increasing passing rates [7].

The EDUCAUSE research indicates that an AI-based adaptive model to create personalised learning experiences for students has great potential to improve student outcomes [1]. Personalised adaptive learning systems generally have long-term potential for teaching, learner attainment and course retention. This has recently been confirmed by results presented at the EDUCAUSE Learning Initiative [9] from a pilot study in a biology course at Arizona State University, which showed a higher student success rate with 18% more students passing and a lower dropout rate, from 15% to 1.5%. This is further supported by Foshee [5], who examined the use of an adaptive learning environment on math remediation, where they found statistically significant improvement in students' learning and math efficacy, indicating that such an environment can lead to successful remediation.

Kerr [11] demonstrated that when personalised adaptive learning systems deliver content in the format determined by assessment to be the best for that student's learning, student learning is enhanced. This notion is further supported by Pugliese [17], who mentioned that "adaptive systems address the fundamentally different levels of prior knowledge, as well as course content progression based on students' skill and outcomes mastery measurement". The personalised and adaptive nature of assessment and feedback systems is also seen as potentially powerful mechanisms for measuring behavioural attributes such as students' motivation as they engage in the learning process [26].

In addition, the remediation provided in the personalised adaptive learning environment assists underprepared students to gain knowledge while still in the course, thus not slowing down their forward educational momentum [4].

In a study conducted by Yang [25], researchers found that when the learning system's interface and learning content were tailored to students' learning and cognitive preferences, it improved the students' learning achievements. These achievements led to an increase in the students' belief in their abilities [13]. In a study conducted by Smith [19], he found that most learners felt that the adaptive learning software integrated with their online course had directed them to helpful content and helped them obtain a deeper understanding.

Additionally, with regard to faculty effectiveness, the implementation of personalised adaptive learning around many institutions has seen a positive effect on lecturer management of progression and curriculum. The Bill & Melinda Gates Foundation, as well as innovative institutions like Arizona State University and the University of Florida, hypothesised that the personalised adaptive learning technologies will provide the key to unlock the "iron triangle" of cost, access, and quality that many see as definitive of challenges in higher education [6].

According to Smith [19], unlike traditional learning, where the instructors find it challenging to identify each learner's understanding of the material, the personalised adaptive learning approach continuously provides detailed information to instructors about each learner's progress towards learning objectives based on materials tailored to their individual progress.

The Horizon Report Expert Panelists in their 2019 Horizon Report [2], discussed the ability of personalised adaptive learning and assessment system and stated that such system allows the instructor to use time typically spent relaying content for more profound learning activities instead (e.g., collaboration around and application of course concepts), which aligns with other areas in this Horizon Report (e.g., Rethinking the Practice of Teaching, Blended Learning Designs, and the Evolving Roles of Faculty with Ed Tech Strategies)".

According to Khamis [12], adaptive learning, however, is not new [20]. It has been implemented in various forms and settings – from group-based classroom instruction to Web-

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based open-space instruction. It was initially used to help students with special needs, such as the need to provide large font size/type and audiobooks. In the 1980s, adaptive learning technology was identified as a means for these special needs students to succeed in a classroom setting. Subsequently, with the emergence of interactive hypermedia, greater computer availability and the dawning of the internet age in the 1990s, the effort to create more effective adaptive and assistive technologies was expanded to other users. Educators have since leveraged technology as a powerful tool for developing and implementing adaptive learning efficiently and effectively. For example, in Singapore, Low [14], conducted adaptive reading comprehension research with Primary 3 Chinese Language (CL) students, and Suryani [20] developed an adaptive learning portal to support the teaching and learning of reading comprehension with primary and secondary Malay Language students.

III. PALAS DEVELOPMENT

A. Description of Portal

The access to PALAS was enabled by the single sign-on (SSO) integration in our NTULearn, the learning management system of NIE-NTU. The learners log in to the NTULearn using the login details provided and click the link to access the PALAS platform. At the homepage of PALAS (Fig. 4), new learners will be recommended the Pre-Course Diagnostic Quiz to determine their mastery level.

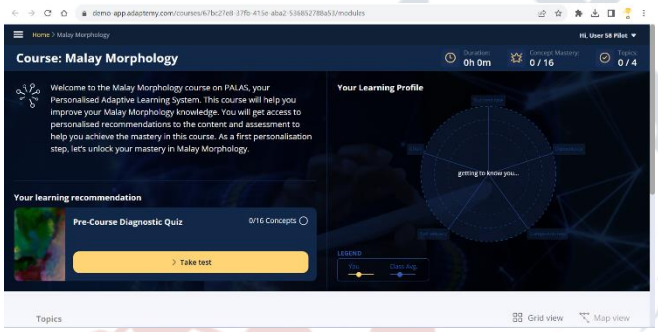

Fig. 4 PALAS Homepage

B. Pedagogical Framework

The pedagogical framework of PALAS (Fig. 5) was developed to lead the development and implementation of personalised learning experience for the learners. This framework contains key activities involved in the design, development, and implementation of PALAS.

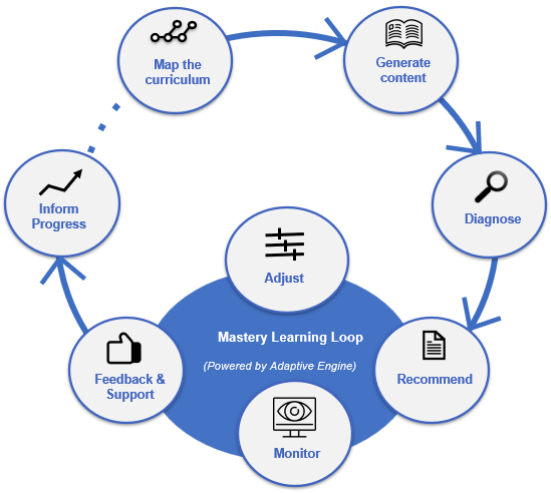

Fig. 5 PALAS Pedagogical Framework

C. Map the Curriculum

The journey of personalising learning begins with curriculum mapping. A curriculum map is a representation of the knowledge and skills set derived from the learning objectives that the instructor expects the learner to achieve. The deliverable of this process is a curriculum map consisting of individual concepts for each topic at the appropriate level of granularity and independently assessable. Using the PALAS authoring site, the tutor breaks down each lesson into granular topics of Malay affixes and indicates the relationship between the concepts (if it is pre-requisite or post-requisite), as shown in Fig. 6. Once the mapping is completed, the tool will generate a curriculum map as shown in Fig. 7.

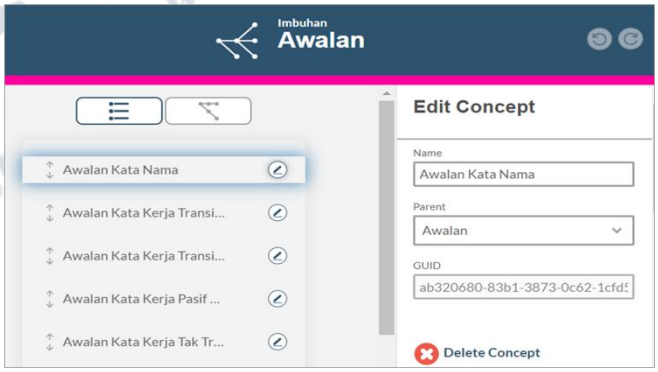

Fig. 6 Curriculum map Creation in Authoring Site

Fig. 7 Curriculum Map

D. Generate Content

The next stage is content development. For each concept derived from the curriculum map, the instructional content, practice and assessment items were developed, and some of

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the instructional items were assigned with the metadata. In PALAS authoring site, we assigned difficulty levels for the practice and assessment items as the metadata. The creation of the content is basically defined by the learning design, which is the mastery loop design (Fig. 8). The mastery loop comprises 4 main types of content to be recommended after the PALAS diagnoses the learners' current mastery. This path consists of instructional content to be delivered as an icebreaker to the topic, followed by concept presentation material. Then, we have guided practice items which are pitched to the learners' proficiency level. The summative assessment is where the system decides if the learners can advance to the next level based on its mastery estimation.

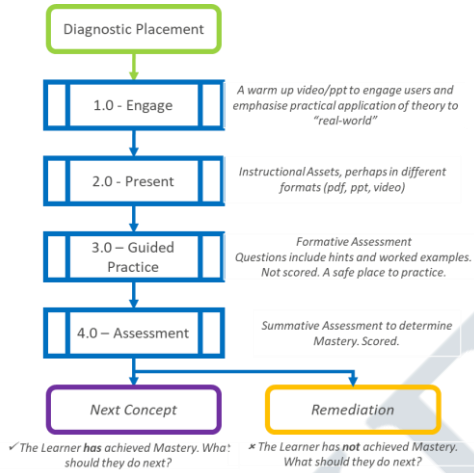

Fig. 8 Mastery Loop Design

In the PALAS content authoring system (Fig. 9), the content is mapped directly to the specific concepts in the form of instructional content, guided practices and assessments.

Fig. 9 Content Authoring

In summary, the mastery loop in the learning design guides the creation of the content. The mastery loop comprises four main types of content (Fig. 10): (i) Engage – introduction, (ii) Present – instruction/lesson, (iii) Guided Practice – explanation/solution provided, and (iv) Assessment – explanation/solution not provided. Therefore, learners will receive immediate scoring and feedback only in Guided Practice. At the end of the Assessment content, PALAS makes a mastery estimation decision on whether the learners can advance to the next level based on their performance.

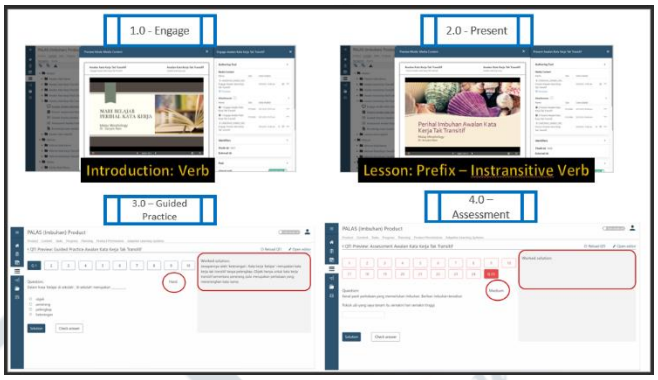

Fig. 10 Different Types of Content/Resources

E. Diagnostic Assessment (Initial Skill Check)

After the curriculum and content are made available. PALAS will diagnose the learner's current mastery level for each sub-topics to personalise their learning of the concepts (Fig. 11). The system diagnoses learner's prior knowledge to measure the entry-level mastery achieved by the learner. This initial data helps the system identify the learning areas where the learner needs to improve, areas the learner has mastered, and the difficulty level of practice items to be recommended.

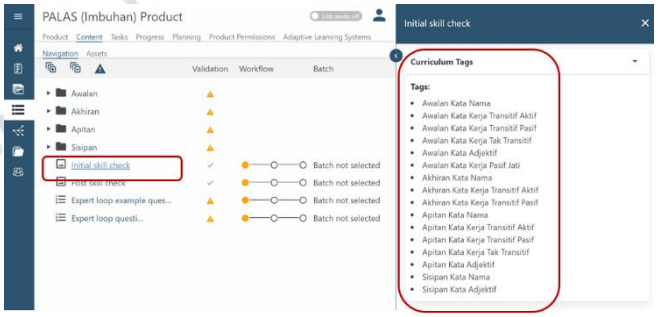

Fig. 11 Initial Skill Check

F. Mastery Learning Loop

Using the results from the diagnostic assessment, PALAS starts with the learner's initial modelling. Additionally, PALAS recognises returning learners based on past learning data. Using these data, the adaptive engine starts directing the delivery of content and the scaffolding that addresses the learner's needs with continuous assessments adapted to their mastery. This process is reflected in the key events of the mastery learning loop, Recommend – Monitor – Feedback – Adjust.

For example, in Recommend, Fig. 12 shows the initial

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recommendation of the topics and the list of concepts to be mastered that the learner sees after completing the diagnostic assessment.

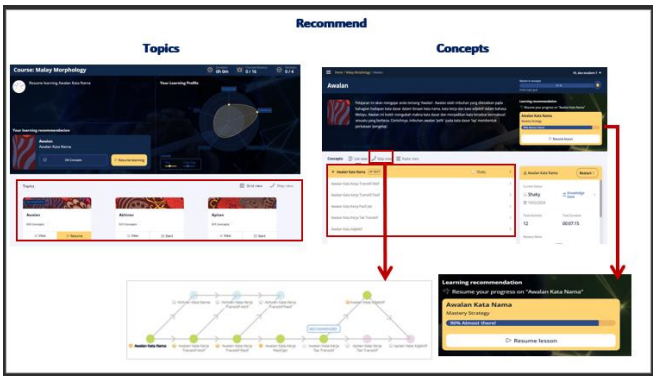

Fig. 12 Recommend

During the learning of the concept, the learners will come across different types of feedback because of the monitoring or tracking of their interactions with the system, such as (i) On-screen tooltips (Fig. 13), (ii) Real-time feedback for practice items (Fig. 14), (iii) Check-in function (Fig. 15), and (iv) Feedback on mastery progress (Fig. 16).

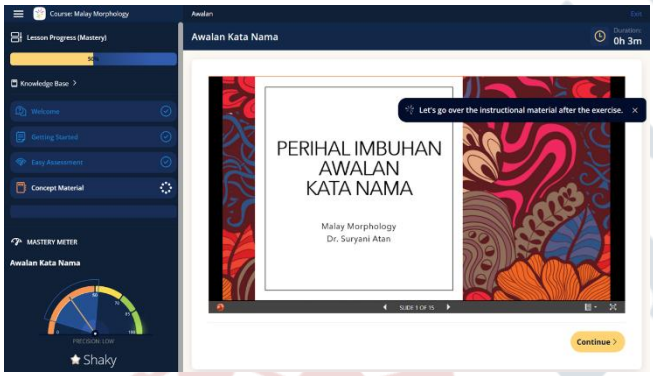

Fig. 13 On-screen tooltips

Fig. 13 shows that the on-screen tooltips appeared when the system detects a completion of an activity or senses a learner struggle. It informs what the learner will see next. Other examples are 'Well done! After successfully finishing the second easy exercise, let's tackle a medium one.' and 'Almost there! Let's tackle a difficult exercise next.'

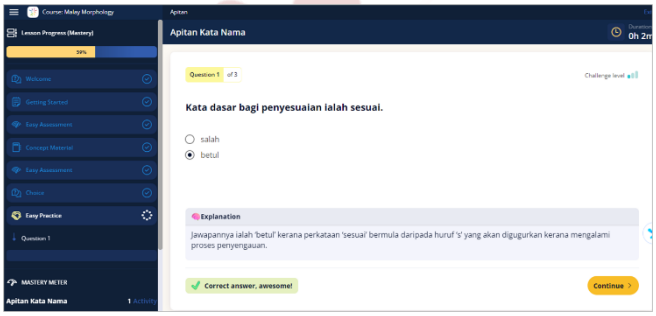

Fig. 14 Real-time feedback for practice items

Fig. 14 shows that feedback is generated after the learner has completed answering a question. Besides checking the learners' responses, it provides the explanation/solution for the questions.

Fig. 15 shows the 'Check-in Function'. It is a pop-up that will appear when the system senses a reasonably long-term struggle like a repetitive failure in easy questions, asking the learner if they want to exit and go to another concept or continue.

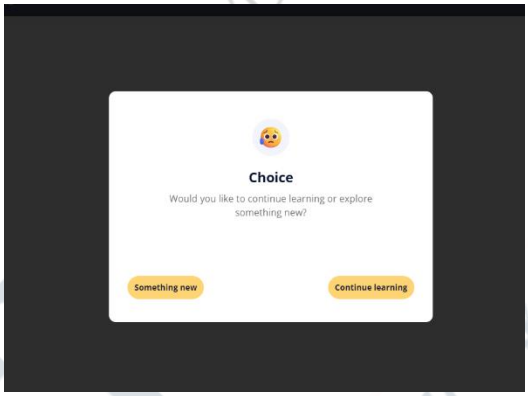

Fig. 15 Check-in function

Lastly, there is feedback on the progress of mastery. The system interface has a mastery meter to inform the learners' current mastery. After the assessment, the learners will receive summative feedback summarising the overall performance and directing them to the next concept if the mastery meter hits the green area (Fig. 16).

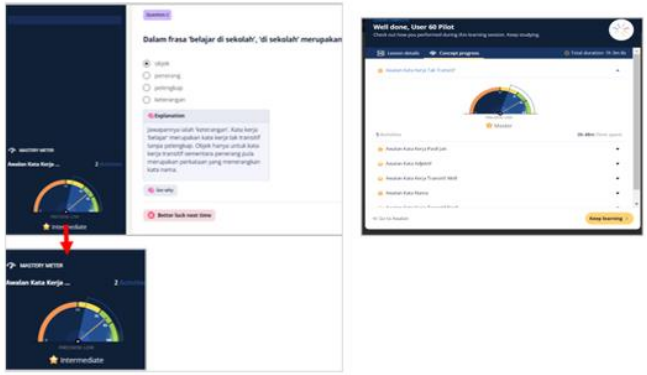

Fig. 16 Feedback on mastery progress

Based on the data obtained from monitoring, the adaptive engine in PALAS will constantly adjust the next course of action in the learning. As a result, PALAS will personalise its recommendations to the learner. The three types of adjustments are (i) difficulty level of questions (Fig. 17), (ii) adaptive sequencing (Fig. 18), and (iii) recommend point-of-need reference (Fig. 19).

Fig. 17 shows how the engine's predictive analytics tools analyse the metrics that determine the difficulty level of questions based on the learner's real-time mastery level. Based on this result, PALAS will render the practice and assessment items in the front-end application accordingly.

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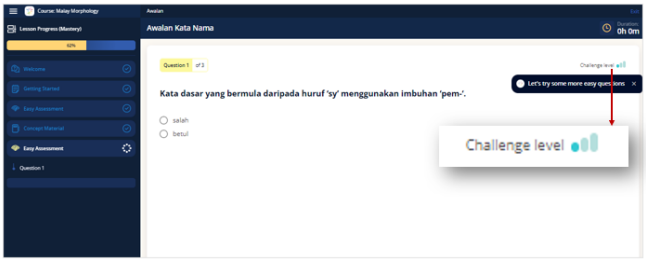

Fig. 17. Difficulty level of questions

The learning data constantly allows for the learners' individualised learning pathway as defined in the mastery learning loop. Each learner will have own path and pace based on their performance level (Fig. 18).

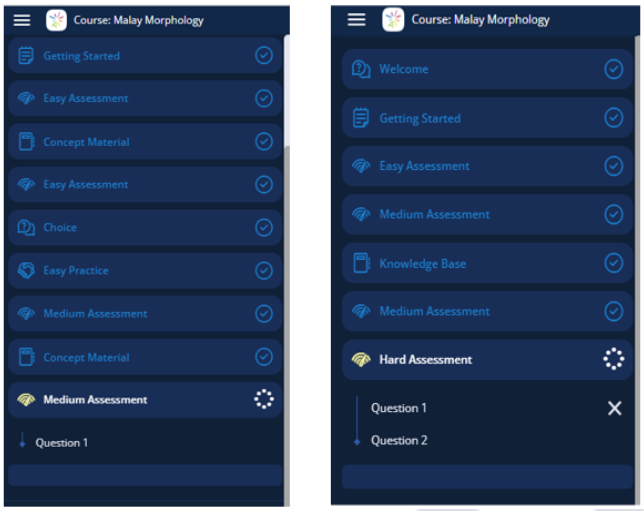

Fig. 18 Adaptive sequencing

PALAS is also supported with supplementary teaching resources embedded in the Knowledge Base. Therefore, apart from adjusting path and pace, PALAS also detects the need to support the learner with supporting materials found in the Knowledge Base (Fig. 19)

Fig. 19 Recommend point-of-need reference

G. Summative Assessment (Post Skill Check)

After the completion of all the 16 sub-topics, the system will prompt the learners to attempt the summative assessment in the Post Skill Check (Fig. 20). The analytics between the Initial Skill Check and the Post Skill Check will provide the information to understand if learning gains have taken place.

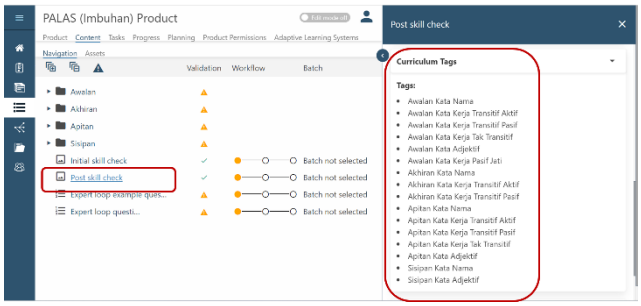

Fig. 20 Post Skill Check

H. Expert Loop Questions

Expert Loop Questions (Fig. 21 – 24) were added in Pilot 2 after reviewing the findings in Pilot 1. Questions set in the Mastery Loop focus on specific sub-topics that the learners are learning. However, questions in the Expert Loop are a combination of topics and sub-topics with easy, medium, and hard difficulty levels. The purpose is to provide learners with more opportunities to learn affixes. They have the flexibility to attempt the Expert Loop questions before or after the Final Skill Check.

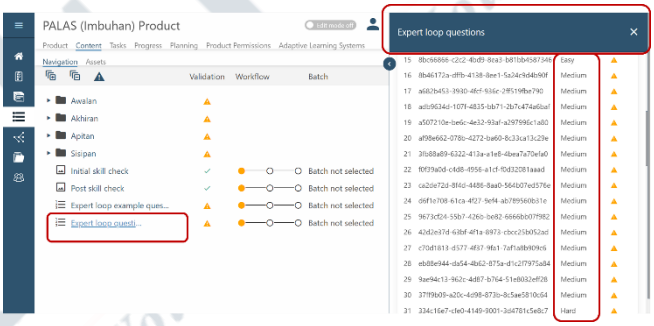

Fig. 21 Expert Loop Questions

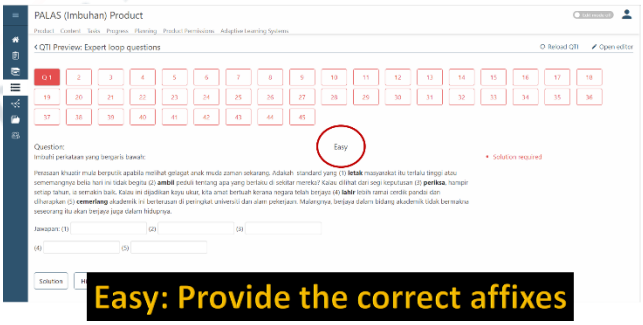

Fig. 22 Expert Loop Questions – EASY

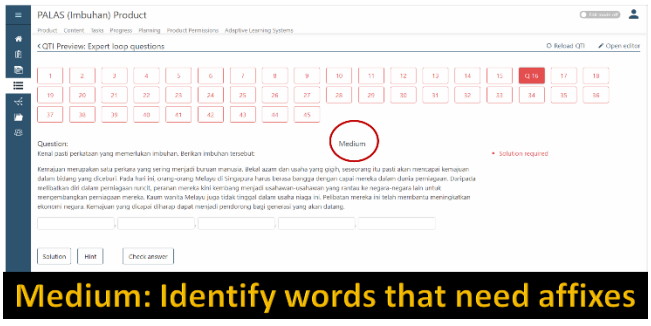

Fig. 23 Expert Loop Questions – MEDIUM

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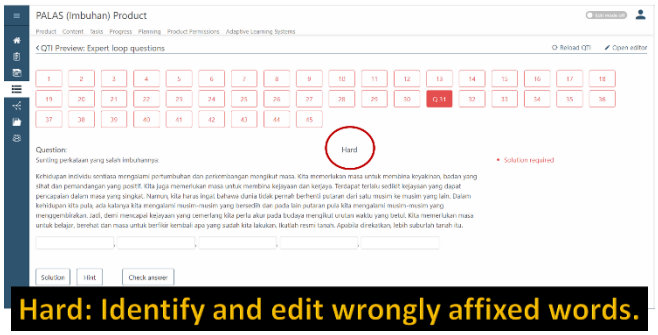

Fig. 24 Expert Loop Questions – HARD

I. Inform Progress

Student-centred learning analytics can offer insights to help instructors understand their learners. When the learners interact with PALAS simultaneously, PALAS also informs the tutor of the real-time progress. The dashboard in PALAS shows the real-time analytics of student progress and course coverage that are available for the tutor to monitor. There are three filters in which the tutor can view the data. Fig. 25 shows the learning analytics of each topic (suffix, circumfix, prefix, infix) by students to see the overall class performance in each of the topics. Fig. 26 shows individual learner mastery in each sub-topic, and Fig. 27 shows the overall class performance for each sub-topic.

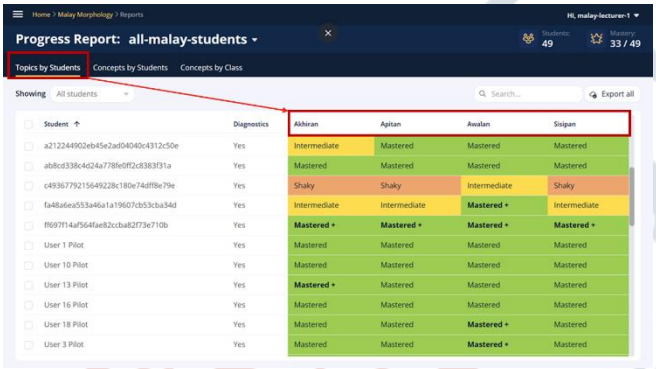

Fig. 25 Learning Analytics for Topics at Student Level

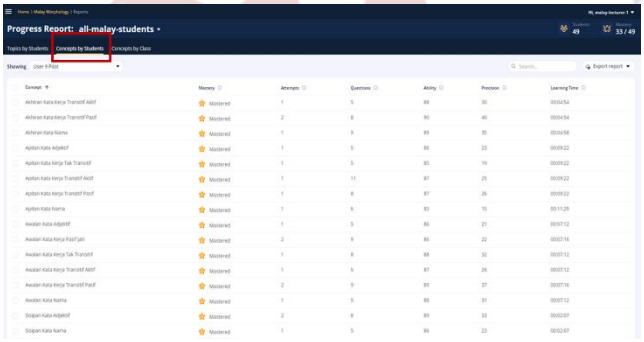

Fig. 26 Learning Analytics of Sub-Topic at Student Level

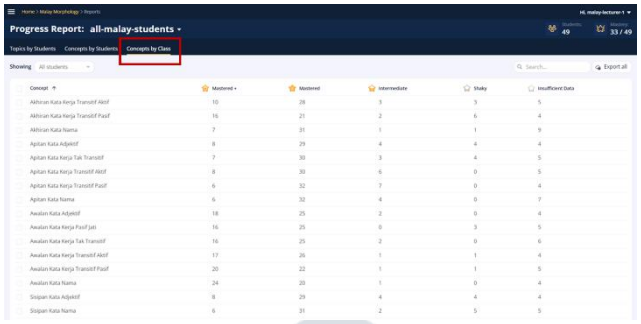

Fig. 27 Learning Analytics of Sub-Topic at Class Level

IV. FINDINGS AND DISCUSSIONS

There are 44 and 53 users in Pilot 1 and Pilot 2, respectively. The students spent more hours in Pilot 1 because they were new to PALAS and navigating it would have taken longer than when compared with Pilot 2. We have also made several improvements to Pilot 2 that have improved the UI and UX. We found that students made more attempts in Pilot 1 than in Pilot 2. We interpreted this as an improvement in their learning. PALAS would require students to try again if they failed to get the correct answer for each question. The findings also show a good coverage of all the 16 concepts available in PALAS (Fig. 28). In summary, the learning gains is medium for both Pilots. However, the effect size is higher in Pilot 2.

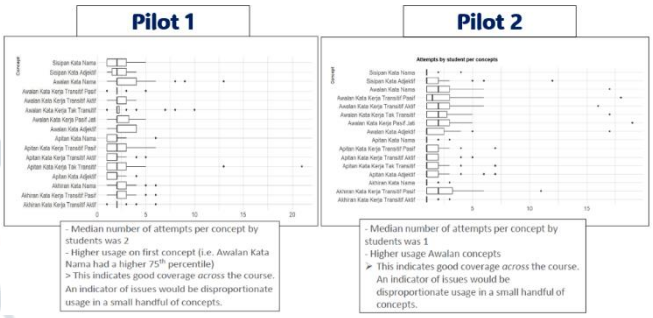

Fig. 28 Attempts Per Concept/Sub-Topic

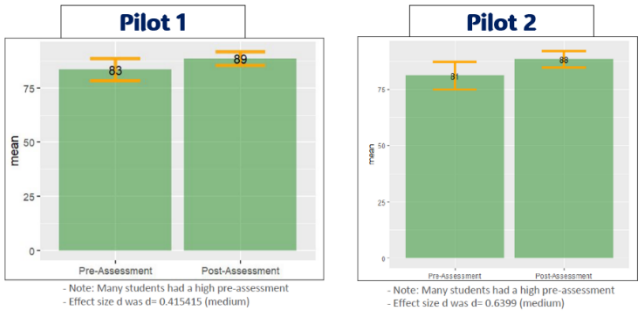

Fig. 29 Overall Learning Gains

The effect size is very positive for both Pilots at the concept level. A very positive effect size of 1.02 was also observed for New Learners. For the content statistics, it was observed that most questions had a high pass rate. We observed very similar concepts pass-rate in both Pilots. Most concepts had a high pass-rate. This is a good indicator for instructors to

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redesign their lessons to provide intervention. Or, as the content provider of PALAS, the author could further calibrate the difficulty level of the content.

A survey conducted for both Pilots showed a positive and sustained high percentage of motivation to learn Malay Grammar and understanding of the grammar topic (Fig. 30). In addition, we received positive feedback on improvement in grammar knowledge and confidence in teaching Malay grammar (Fig. 31).

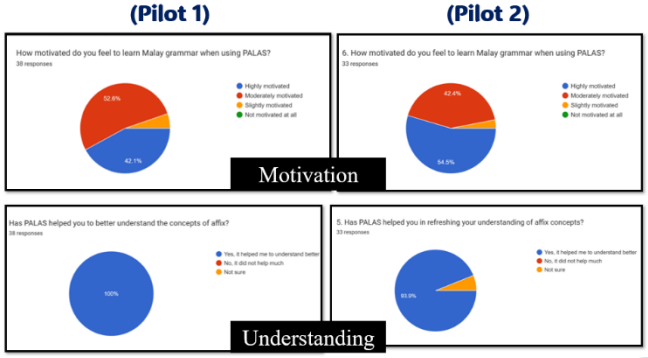

Fig. 30 Feedback on Motivation and Understanding

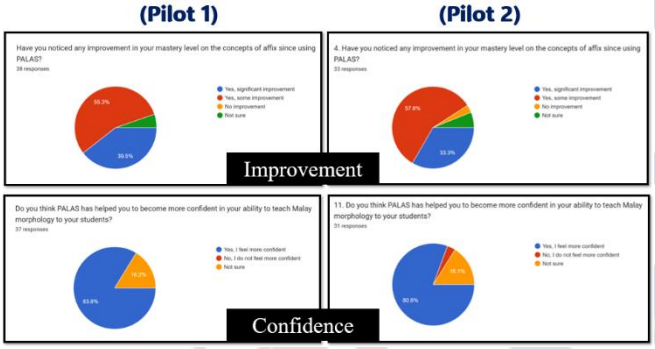

Fig. 31 Feedback on Improvement and Confidence

V. CONCLUSION

PALAS has shown evidence of good and reasonable effect size learning gains. It can potentially expand to other grammar topics in morphology and syntax.

VI. ACKNOWLEDGEMENT

Thank you to the NIE Teaching and Learning Committee (TLC), National Institute of Education (NIE) – Nanyang Technological University (NTU), Singapore, for making the Incentivising ICT-Use Innovations Grant (I^3G) available for this project.

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