

**Invitation to Expression of Interest
for Construction of Student Adaptive Learning System
for the Education Bureau of
the Government of the Hong Kong Special Administrative Region**

File Reference: EDB(BCA)/P&S/5/2019/59

Outline Brief

1. Introduction

- 1.1 The Education Bureau (EDB) of the Government of the Hong Kong Special Administrative Region (the Government) intends to engage a Service Provider (please also see paragraph 5.3) to design, construct and maintain a computer-aided and interactive Student Adaptive Learning System (SALS). This outline brief provides the background information, objectives and scope, proposed development framework, envisaged team structure and intended mode of collaboration, as well as the system components of SALS.

2. Background Information

- 2.1 To recommend directions for the development of Basic Competency Assessment and enhancement of assessment literacy among schools, EDB tasked the Coordinating Committee on Basic Competency Assessment and Assessment Literacy (the Committee) to conduct a comprehensive review on the arrangement of Territory-wide System Assessment in 2015. In its report released in 2016, the Committee suggested EDB to conduct a study to explore how to carry out assessments with the aid of computers and interactive tools to enhance the function of providing feedback to schools. In its report released in 2018, the Committee also suggested EDB to continue developing quality online resources for the learning-teaching-assessment cycle, including intensifying pilot projects on student adaptive learning (SAL) to help schools cater for learner diversity, and providing learning and teaching materials appropriate to the learning progress of individual students to facilitate self-learning. EDB has thus explored the use of advanced information technology to develop an SALS that may render more instant, effective and interactive analysis and feedback for both students and teachers.
- 2.2 The SALS may provide stipulated learning paths in the development of related concepts, knowledge and skills in respective subjects of Chinese Language, English Language and Mathematics. In collaboration with local tertiary institutions, EDB has developed and validated related knowledge structures, which serve as guide

maps for various feasible learning paths for the three subjects concerned. Three pilot studies on the development of knowledge structures and sample assessment tasks and questions for selected dimensions of the Chinese Language, English Language and Mathematics subjects at Key Stage 1 (KS1)¹ were conducted between 2017 and 2018. Three research projects on development of knowledge structures and sample assessment tasks and questions for selected dimensions of the three subjects concerned at KS1 and KS2² have also been commissioned and will complete by early 2020. Based on the outcomes and experience gained in these projects, the direction for the development of knowledge structures, learning resources, as well as assessment tasks and questions for specific dimensions of the three subjects at KS1 and KS2 has been set. An overview of knowledge structures of the three subjects and relationships between knowledge structures, learning resources and assessment tasks and questions are provided at [Annex I](#).

- 2.3 The proposed SALS may make use of computer-assisted assessment technology to cater for learning diversity. The SALS may contain features that support a personalised learning path in the design and delivery of learning resources as well as assessment tasks and questions, so as to cater for the personal learning needs of students, improve their performance, and enable them to learn effectively and achieve the desired learning outcomes. Proper use of artificial intelligence in identifying students' learning needs, analysing the performance of students as an individual and a group, providing feedback to teachers, allowing the development of big data of students' learning characteristics and patterns, and in the longer term, allowing teachers to contribute validated assessment tasks/questions to the SALS, would definitely enhance the system design.

3. Objectives and Scope

- 3.1 The SALS may consist of two components, encompassing **adaptive learning** and **adaptive testing**. The former component may be named as 'Learning Zone' while the latter component may be named as 'Testing Region'. Learning and testing resources shall be provided in the two components and they include assessment tasks and questions and learning resources which are developed with reference to the knowledge structures. Assessment data would be generated when students work on the assessment tasks and questions. Based on these data, the SALS would automatically operate in a way that engages students in adaptive learning. The SALS is expected to provide user-friendly feedback to students, teachers and schools, and to make available multimodal learning resources appropriate to the learning progress of individual students to facilitate self-directed learning.
- 3.2 EDB shall provide the detailed knowledge structures, learning resources, assessment tasks and questions of selected dimensions of the Chinese Language, English Language and Mathematics subjects for students from KS1 to KS2.

¹ KS1 refers to Primary 1 to 3.

² KS2 refers to Primary 4 to 6.

The Service Provider of the SALS project would be expected to deliver the following:

- (i) construction of the SALS, including but not limited to providing Information Technology (IT) infrastructure for the system and necessary allowance in its design to the setting up of a collaborative learning environment (possibly in the form of a sub-platform) in which individual schools can contribute to the item bank for storing assessment tasks and questions for developing their school-based SALS in the longer run. The infrastructure refers to appropriate hardware and software such as servers, storage devices and network resources, setting up databases for the following categories: (I) all system administrators and users; (II) knowledge structures; (III) learning resources; and (IV) assessment tasks and questions;
- (ii) design of the SALS, including formulation and implementation of programming algorithms based on sound knowledge of the curricula of the Chinese Language, English Language and Mathematics subjects for KS1 and KS2, for example, in assigning assessment tasks and questions to students, providing instant feedback on students' mastery of concepts and skills, analysing student assessment based on analysis of cumulative student assessment data; and data with adequate approaches to psychometric analysis, and re-ranking of assessment tasks and questions according to their levels of difficulty at regular intervals
- (iii) maintenance of the SALS, including provision of helpdesk support and enhancement services as well as the potential migration of the SALS due to the reasonable technological advancements and operational needs in future with the view to sustaining the implementation of the SALS in the long run.

3.3 The scope of the SALS project may cover the following subjects, dimensions and student levels:

- (i) Chinese Language: Reading (KS1 and KS2);
- (ii) English Language: Reading (KS1 and KS2); and
- (iii) Mathematics: Measures Strand (KS1 and KS2) and Shape and Space Strand (KS1 and KS2).

3.4 The Service Provider will need to collaborate with and receive instructions from EDB regularly to develop the SALS by phases.

4. Proposed Development Framework

4.1 Some necessary elements of a proposed development framework of the SALS are provided at **Annex II**.

5. Envisaged Team Structure and Intended Mode of Collaboration

- 5.1 In view of the complexity of the SALS project, experts/professionals from the following fields are deemed necessary:
- (i) **Computer engineering/information technology**: To construct, maintain and enhance the SALS, make recommendations on the provision of incentives to arouse and maintain students' interests in using the system (e.g. incorporating gamification elements where appropriate and making recommendations on the student award system);
 - (ii) **Expertise from the education arena (including subject expertise and education professionals)**: To provide advice or views on the learning routes suggested by EDB or redesign the learning routes for adaptive learning and testing with reference to the knowledge structures of specific dimensions of the Chinese Language, English Language and Mathematics subjects for KS1 and KS2, and the assessment tasks and questions as well as learning resources to be provided by EDB; and
 - (iii) **Psychometric analysis**: To run and analyse student assessment data with adequate approach(es) to psychometric analysis, identify students' strengths and weaknesses, produce statistical graphs for providing feedback to students, teachers and schools, and distribute suitable assessment tasks and questions and learning resources to support a personalised learning path for individual students.
- 5.2 The expertise from the education arena shall be a group of academics or professionals who have in-depth knowledge in the field of education or specific subjects, i.e. Chinese Language, English Language and Mathematics. In addition to academic knowledge, the subject expertise shall have rich experience in applying educational theories in practice.
- 5.3 Since experts/professionals from different fields are required, **collaboration among different firms/faculties of universities/tertiary institutions may be necessary to formulate the team as the Service Provider for the project on the construction of the SALS.** As a general principle, the future Service Provider shall be a body corporate incorporated under the Companies Ordinance (Cap. 622), the Registered Trustees Incorporation Ordinance (Cap. 306) or any other statute for the provision of the services subject to and in accordance with the terms and conditions as set out in the future service agreement.
- 5.4 During the preparation stage, EDB has identified challenges that require specific advice from academic experts or education professionals, two of which are provided at **Annex III**.

6. System Components

6.1 The Service Provider would be expected to devise, design, develop and provide the following components of the SALS.

(i) Infrastructure of the SALS

The Service Provider may:

- (a) provide the IT infrastructure for the SALS, including but not limited to the SALS platform, database storage (e.g. cloud services) or all necessary hardware and software for operating the system;
- (b) establish and build at least **four** databases, one for the system administrators and users, one for the knowledge structures, one for the learning resources and one for the assessment tasks and questions; and
- (c) set up designated sub-databases for different administrators and users for different purposes.

There will be several types of system administrators and users, including but not limited to EDB administrators (analyst programmers), EDB users (curriculum officers), school administrators (IT coordinators of individual schools), school users (school heads, curriculum leaders, teachers) and students using the SALS for self-directed learning. The Service Provider may need to advise the ordinary performance functions that enable the efficient and effective usage/management of the SALS, examples of which are as follows:

- (I) **EDB administrators**: Performing functions including but not limited to adding or deleting users and updating EDB or school users' profiles;
- (II) **School administrators**: Performing functions including but not limited to retrieving their students' assessment data at school level and downloading relevant reports generated by the SALS;
- (III) **Teacher users**: Performing functions including but not limited to monitoring individual students' involvement and progress, retrieving their assessment data at class level and downloading the relevant data to compile reports; and
- (IV) **Student users**: Performing functions including but not limited to working on the assessment tasks and questions according to their own learning progress and difficulties, and making use of the learning resources to tackle the difficulties encountered and engage in extended learning.

- (d) The Service Provider may establish and build a learning resource bank for storing resources including but not limited to video clips, PowerPoint videos, worksheets and games. The resources may include interactive elements. Although the Service Provider does not need to develop learning resources, a user-friendly interface for listing and updating the learning resources has to be developed. The updates would include, amongst others, adding new learning resources, updating the existing learning resources and removing obsolete learning resources.
- (e) The Service Provider may set up an item bank for storing the assessment tasks and questions of different levels of difficulty. While ranking of the assessment tasks and questions may be revised by the SALS at regular intervals agreed between the Service Provider and EDB with reference to analysis of cumulative student assessment data, the levels of difficulty of the assessment tasks and questions may also need updating. Although the Service Provider may not need to develop assessment tasks and questions, a user-friendly interface for listing and updating the assessment tasks and questions has to be developed. The updating shall include, amongst others, adding new assessment tasks and questions, re-ranking the existing assessment tasks and questions and removing obsolete assessment tasks and questions as well.
- (f) The Service Provider may make use of existing software, programme(s) and platform(s) as a basis of development. The Service Provider shall be responsible for handling matters related to the copyright of such software, programme(s) and platform(s) and such cost should be reflected separately as far as possible in the future price proposal at the tendering stage.
- (g) If the Service Provider would like to suggest using certain existing student learning software as the basis of development, the content of such software shall be designed in line with the central curricula of the subjects concerned.
- (ii) Adoption of Computerised Adaptive Testing (CAT) and Psychometric Analysis
- (a) CAT is a form of computer-based test that adapts to the examinee's ability level. It is also called tailored testing. SALS may adopt CAT and assign or distribute assessment tasks and questions that adapt to students' ability levels, i.e. administering the next set of tasks and questions based on the performance in the most recent sets of tasks and questions administered.
- (b) There are many approaches to psychometric analysis, such as the Item Response Theory (IRT) Model and Cognitive Diagnostic Model (CDM). IRT can be used for scaling the assessment tasks and questions based on students' responses to any given assessment task or question. The Rasch model can be applied when IRT is adopted as it is flexible when the size changes and its interpretation is relatively simple. CDM is useful for

identifying specific skills students have and have not mastered. The Service Provider may suggest other approaches to psychometric analysis. Subject to further exploration, the Service Provider may need to adopt one or more of the above approaches.

(iii) Development of a Prototype of the SALS

- (a) The Service Provider may propose the design rationale and the framework for the SALS.
- (b) To facilitate understanding of the operation of the SALS, the following example, not meant to be the only restrictive approach, is provided for reference. When students use the SALS for the first time, assessment tasks/questions shall be assigned for preliminary assessment. Data on students' performance shall then be analysed and relevant statistical graphs (e.g. item-person maps and boxplots on students' performance) shall be generated. Meanwhile, the difficulty, discrimination and fit statistics of individual assessment tasks/questions are calibrated. Ranking of the levels of difficulty of assessment tasks and questions shall be revised at regular intervals based on analysis of cumulative student assessment data. A simplified flow chart is provided at Annex IV.
- (c) Other than the assessment component, the SALS shall also consist of another component related to learning. Students shall find out where they are located in the knowledge structures after completing some assessment tasks and questions. In other words, the SALS shall be able to find out which skills/learning outcomes they have mastered/achieved, as well as which skills/learning outcomes they have not. To distribute the next suitable sets of assessment tasks/questions or learning resources to students, the Service Provider shall define the learning as well as the termination routes for the specific dimensions of the Chinese Language, English Language and Mathematics subjects for KS1 and KS2.
- (d) When students complete a designated number of assessment tasks and questions with pre-determined and prescribed performance, they may earn motivational rewards like 'stickers' or 'stars'. However, the rewards may reduce in number or disappear if students cannot complete those assessment tasks and questions at a satisfactory level in the following attempts. The Service Provider may make recommendations on the reward system.
- (e) The SALS may be multimodal. Game elements are considered an attractive feature that may also be introduced to the SALS to attract students to continue working on the assessment tasks and questions as well as learning resources.

(iv) Mandatory IT service during the Development of the SALS

- (a) The Service Provider may perform load tests to confirm that the system capacity is sufficient for handling the specific workload requirements. The Service Provider may set up a proper system environment for the Government to carry out the User Acceptance Tests (UAT). The Service Provider may request a third independent party to carry out Security Risk Assessment and Audit (SRAA) before the rollout. All the related issues arisen from the SRAA exercise should be handled properly. A disaster recovery plan, i.e. performing periodic backup and restoring the SALS together with the related data in case of emergency, has to be proposed for EDB's endorsement.
- (b) It is expected that the SALS may be developed and constructed by phases within three years. The estimated annual number of student users is as follows:

	Chinese Language/ English Language/ Mathematics
Primary students (KS1 & KS2)	67 000 per subject

There may also be about 3 000 others types of users such as EDB administrators, EDB users, school administrators and school users.

(v) Graphic Design

- (a) The Service Provider may provide the graphic design service to develop the SALS which fulfils the common look and feel standard promulgated by the 'Guidelines on Dissemination of Information through Government Homepages' (Link: https://www.ogcio.gov.hk/en/our_work/community/web_accessibility/doc/disseminationguidelines.pdf).
- (b) The design templates may cover normal browser mode, including browsers used by devices including mobile phones and tablets. Considerations shall be given to cater for requirements of different mobile devices and operating systems, including those consequential to the related regular updates.
- (c) The Service Provider may prepare design templates comprising the cover page and contents pages of the SALS.
- (d) The Service Provider may provide design templates in the form of dress up prototype, templates, cover and contents pages and/or artworks, and be responsible for picture research, image sourcing and/or artworks, image

retouch. A dress up prototype is referred as the one which fulfils the common look and feel standard mentioned in part (a) of this Clause. The design is subject to modifications after receiving written comments from EDB.

(vi) System Nursing

- (a) The Service Provider would be expected to provide a prototype of the SALS for EDB to perform internal testing. After that, EDB may invite some schools to join a trial run. During the trial run, the Service Provider may provide system nursing and support until all the issues raised are successfully resolved.
- (b) During the nursing period, the Service Provider may provide the following service:
 - I. helpdesk service;
 - II. problem determination, management and bug fixing;
 - III. ad-hoc change request and system installation/enhancement;
 - IV. system monitoring & optimization; and
 - V. production support and ad-hoc processing requests.

(viii) Training for Users

- (a) The Service Provider may prepare all the training materials as instructed by EDB (e.g. user manuals and video clips in both Cantonese and English) for all SALS users.
- (b) The Service Provider may prepare all the handover documents, provide all source codes and deliver training sessions to another Service Provider by the end of the Contract and/or in case of potential migration of the SALS due to the reasonable technological advancements and operational needs in future with the view to sustaining the implementation of the SALS in the long run

(ix) Provision of Helpdesk Support, Maintenance and Enhancement Service

- (a) The Service Provider may provide helpdesk support for all SALS users. Maintenance service for 24 months after rollout is needed, and may be extended subject to future developments of the SALS and operational needs.
- (b) Enhancement service may also be required for adding new functions/features or updating the existing functions/features in the SALS. The Service Provider may review EDB's requirements and propose further enhancement. Besides, the project may cover more dimensions/strands in each subject later, so storage space has to be reserved and the programme coding should cater for further development of the SALS.

(x) Monitoring and Evaluation of the SALS Project

- (a) Regarding the SALS project, the Service Provider may propose the criteria and data to be collected for monitoring and evaluation of the SALS project. EDB may assist in collecting data from schools. The Service Provider may make use of the collected data and identify areas where further improvement can be made in achieving the objectives of the SALS project.
- (b) While a full report covering the whole period of the SALS project may be produced, bi-yearly reports on the operation of the SALS may also be required.

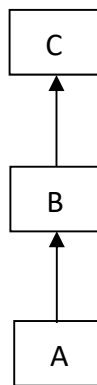
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Knowledge Structures

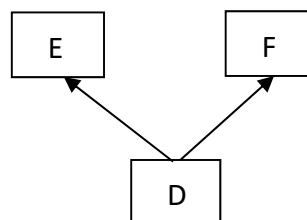
A knowledge structure represents the relationship between concepts and skills that may be hierarchical, linear, grouped or independent. It can be created hypothetically based on the nature of the subject matter for the purpose of creating adequate learning experiences. Therefore, the relationship between the curriculum standard and students' learning experiences is often highlighted. A valid knowledge structure is a guide map for various feasible learning paths between the relevant concepts and skills. Simplified examples of knowledge structures of the Mathematics and the two Language subjects are given below.

Knowledge Structures of the Mathematics Subject

There are three concepts/skills, namely 'A, B and C', which are hierarchically or linearly related to each other. Concept/skill 'A' is the prerequisite for concept/skill 'B' whereas concept/skill 'B' is the prerequisite for concept/skill 'C'. The knowledge structure of these three concepts/skills can be illustrated by the following figure:

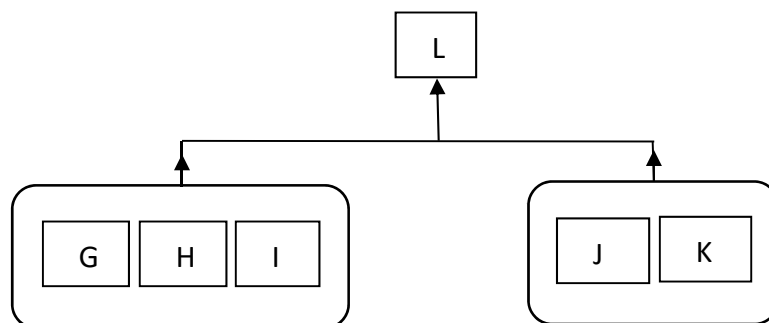


A more sophisticated scenario may include multiple concepts/skills at one level (mostly not more than three). Three other concepts/skills 'D, E, F' are also hierarchically or linearly related to each other. Concept/skill 'D' is the prerequisite for concepts/skills 'E and F' whereas concept/skill 'E or F' is not the prerequisite for concept/skill 'F or E'. The knowledge structure of these three concepts/skills can be illustrated by the following figure:



Knowledge Structure of the English Language and Chinese Language Subjects

Two groups of concepts/skills ‘G, H, I’ and ‘J, K’ are the prerequisites for concept/skill ‘L’. These two groups of concepts/skills are not hierarchically or linearly related to each other. The knowledge structure of the concepts/skills can be illustrated by the following figure:



Illustrations of knowledge structures of the Mathematics, English Language, Chinese Language subjects are attached at the end of this Annex for reference.

In the contexts of different subject areas, learning resources are developed with reference to relevant knowledge structures to facilitate adaptive learning. They may include but not limited to videos, PowerPoint slides, worksheets and games. Those learning resources may encompass interactive elements.

Assessment tasks and questions are also designed with reference to relevant knowledge structures to facilitate adaptive testing. They are ranked according to their levels of difficulty. Students’ learning difficulties can also be identified for follow-up actions. Data on students’ mastery of the concepts and skills can be collected and analysed to provide feedback to students, teachers and schools.

Illustration of the Knowledge Structure of Mathematics Subject (Unit 'Money' for Primary 1)

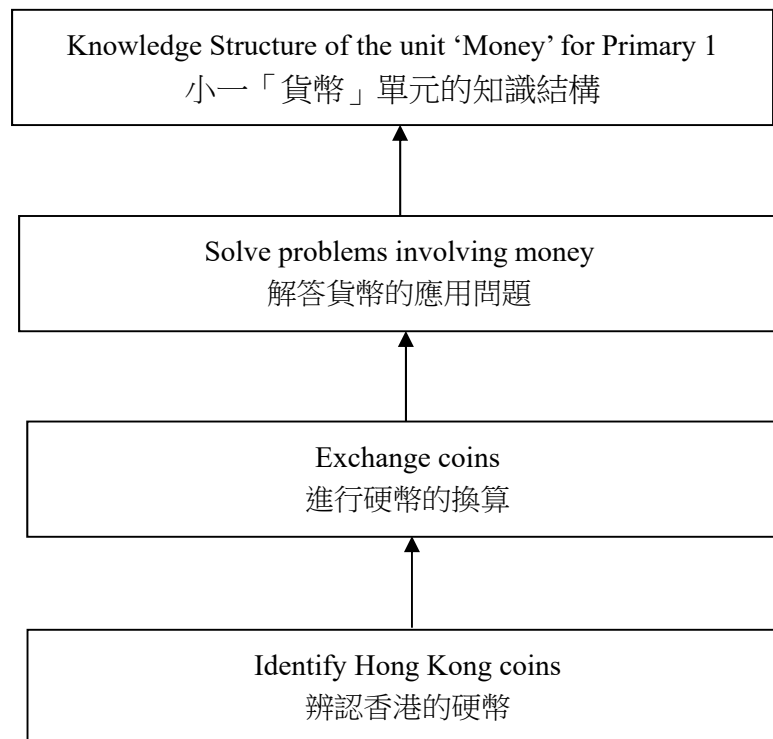


Illustration of the Knowledge Structure of English Language Subject (Reading for KS1 and KS2)

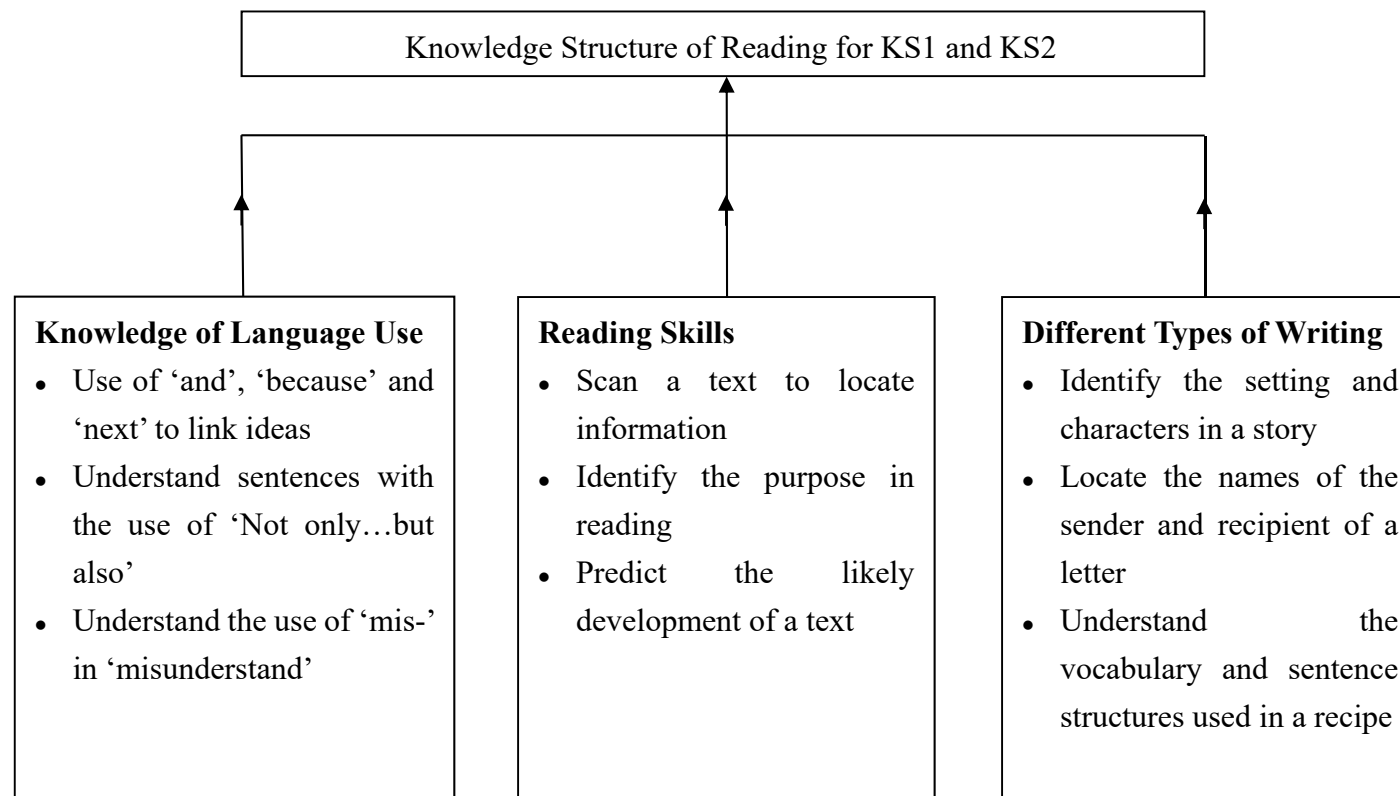
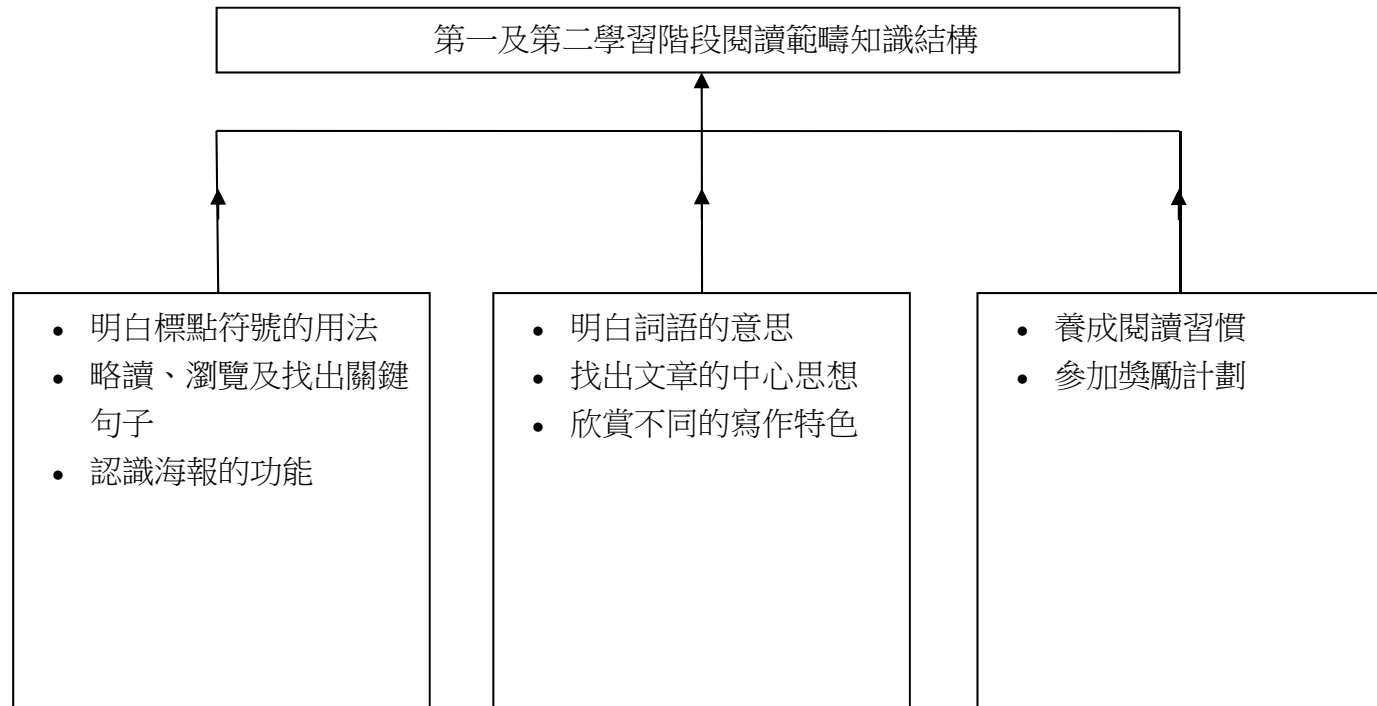
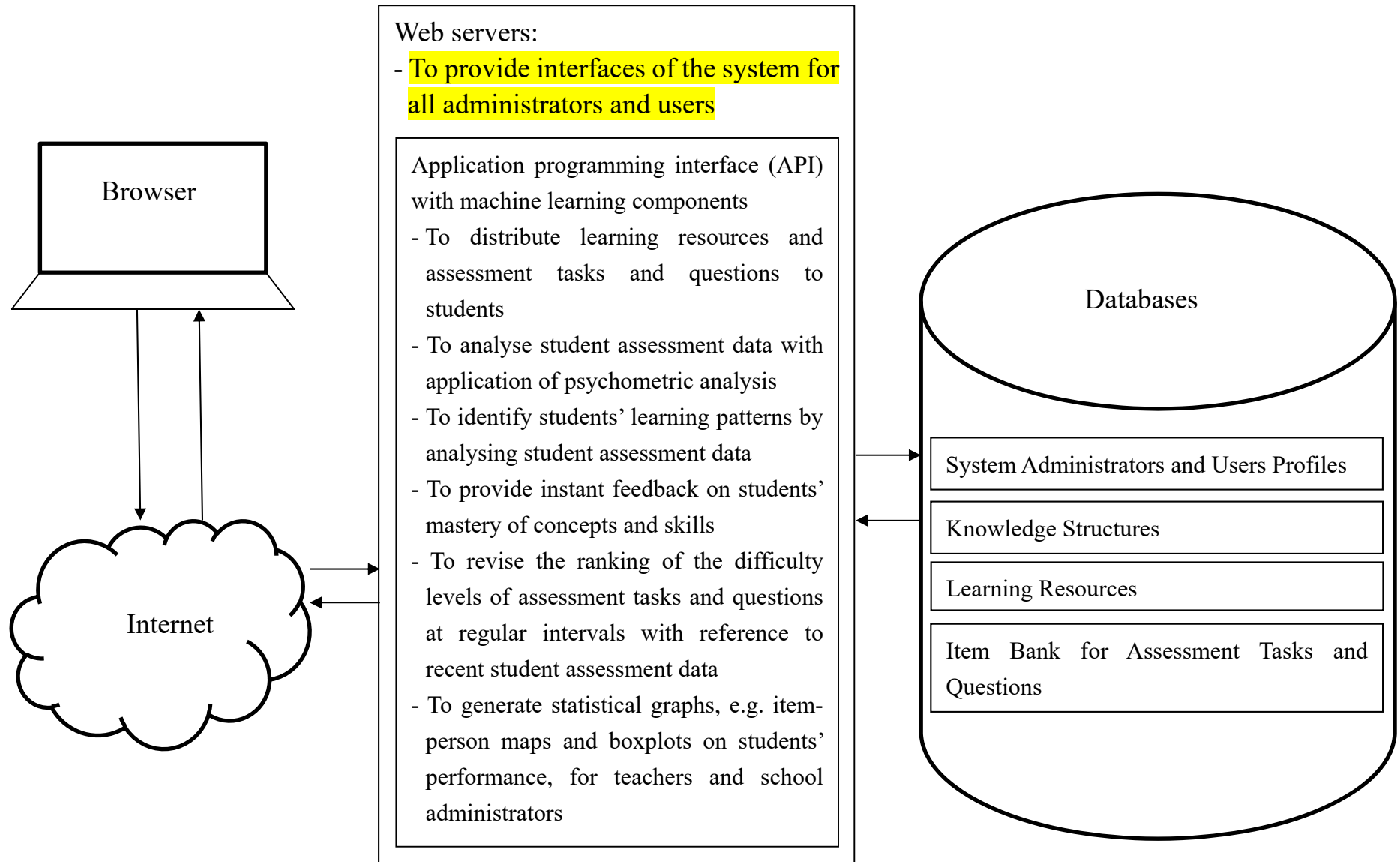


Illustration of the Knowledge Structure of Chinese Language Subject (Reading for KS1 and KS2)



Proposed Development Framework of the SALS



Challenges Identified

During the preparation stage of the SALS project, EDB has identified two challenges that require advice from academic experts or education professionals.

Challenge 1: Differences between knowledge structures of the Mathematics subject and the two Language subjects

While the relationship between concepts and skills in the knowledge structures of the Mathematics subject is hierarchical, the concepts and skills in the Chinese Language and English Language subjects are grouped. Based on the above differences, it is expected that, amongst others, the assessment routes and learning routes will be different to a certain extent.

Challenge 2: Ranking of assessment tasks and questions

Assessment tasks and questions are ranked according to their levels of difficulty. While assessment questions are set for the Mathematics subject, assessment tasks (a text and a few assessment questions) are set for the two language subjects. Assessment questions can be ranked by their levels of difficulty. The ranking of assessment tasks which consist of texts and assessment questions may have to be further explored.

Ranking of Assessment Tasks and Questions

