1 Assumptions on the question content

1. The questions should cover all skills required in the curriculum.
2. We do not have many questions testing exactly the same skill. This can be done by obtaining questions from one publisher only.
3. Questions are graded into levels 1 and 2, with level 1 being easier and level 2 being more difficult. The level 2 questions together cover all skills required in the curriculum.

2 Absolute difficulty of a question

The absolute here means it is not affected by the other questions. The absolute difficulty of a question is defined as the percentage of students in that form (such as Form 4) not being able to finish it. It is assumed that there is no question with absolute difficulty 0% or 100%.

3 Relative difficulty of a level 2 question

The relative difficulty of a level 2 question is defined as its absolute difficulty divided by the maximum absolute difficulty among all level 2 questions in the same concept, rounded to the nearest 1%. There must be at least one question in each concept having relative difficulty 100% by definition.

4 Base difficulty of a concept

The base difficulty of a concept is defined as the minimum relative difficulty among all level 2 questions in the concept. It can be assumed that this number is not close to 0%.

5 Relative difficulty of a level 1 question

The relative difficulty of a level 1 question is defined as the base difficulty of the concept times the absolute difficulty of the question, rounded to the nearest %. It can be assumed that all level 1 questions have relative difficulty significantly less than any level 2 questions.

6 Dynamicities of difficulties

Note that both absolute and relative difficulties of a question can always change because the dataset is changing. However, when the dataset is large, the changes will not be large.

7 Difficulty rank

The relative difficulties are ranked in ascending order (note that the rank is dynamic). Ties are broken randomly.

8 Understanding level of a concept

The understanding level of a concept is defined as the percentage such that in the concept

1. this percentage is the relative difficulty of some question; and
2. all questions at this relative difficulty or below is finished

with the exception that the understanding level of a concept is 100% if all level 2 questions are finished. Note that understanding level is dynamic.

9 How students do exercise

A student starts at either level 1 or level 2. The student can choose by himself/herself or ask us (i.e. the AI) to choose for him/her. The AI model is to be developed.

10 The case when the student starts at level 1

1. The system computes the difficulty rank. When the difficulty rank is being considered, this rank is always referred to until the student achieves a perfect understanding level. When the student achieves a perfect understanding level, this rank will be cleared. If the difficulty rank is being considered later, it will be computed again.
2. The student starts with the question having the lowest difficulty rank.
3. If the student finishes a question, the next question given is the question with the lowest difficulty rank among all unfinished questions.
4. If the student skips a question (denote the question by x), the next question given is the so-called easiest question among all unfinished questions ranking higher than x. This is to avoid loops in our best effort. The next question is even more difficult by assumption, but the selection is logical because this question may be easier than x in the view of the student.
5. If a student exits and starts the exercise again, the question given will be the question with the lowest difficulty rank among all unfinished questions.
6. I hope this flow is logical.

11 The case when the student starts at level 2

1. The system computes the difficulty rank. When the difficulty rank is being considered, this rank is always referred to until the student achieves a perfect understanding level. When the student achieves a perfect understanding level, this rank will be cleared. If the difficulty rank is being considered later, it will be computed again.

2. The student starts with the level 2 question having the lowest difficulty rank.

3. If the student finishes a question, the next question given is the level 2 question with the lowest difficulty rank among all unfinished questions.

4. If the student skips a question, the student starts the exercise again as if those who start at level 1.

5. If a student exits and starts the exercise again, the question given will be the level 2 question with the lowest difficulty rank among all unfinished questions.

6. I hope this flow is logical.

12 Grade

The grade of a student can be determined as follows:

1. It is assumed that the students have taken at least one internal exam (i.e. exam administered by the school) before buying our service. It is not suggested that the school gives the students an exam just for the app, otherwise some students may pretend not knowing the questions.

2. By the above assumption, each student has a latest rank. Even if a student was absent from the latest exam, the previous rank can be used.

3. Each student is assigned a percentage rank (no rounding). The percentage ranks will be converted to grades.

4. The grading is done by one simple rule. If x% of the Form 6 students in the school get 5** in DSE Math last year, then the top x% get 5**. If y% of the Form 6 students gets 5* in DSE Math last year, then the next y% get 5*, etc.

It is not necessary that this method is used. Teachers may assign the grades by any other method they want to use. There may also be special cases such as a new school not having DSE classes before. In such cases, teachers must assign the grades by themselves.

13 Cumulative understanding level (c)

The cumulative understanding level c is defined as the weighted mean of the understanding levels of all concepts assigned by the teacher, rounded to the nearest 1%. The weight of a concept is given by its number of level 2 questions. Weights are assigned because the complexities of different concepts may be very different. The cumulative understanding level at the end of a day (i.e. at midnight) is recorded. This will be part of our dataset for future use. For convenience, 29th February will be considered as part of 1st March. I suppose this is not causing a big problem.

14 Improvement base (b) and improvement score

Suppose it is at the noon of 1st October and a Form 4 student is doing a question.

1. The c value keeps changing because there are probably other students doing questions as well.
2. At this moment, we have all Form 4 students' c values at noon today.
3. We also have the previous Form 4 students' c values at the end of 1st October.
4. The data in (2) and (3) are grouped together and then split into 8 grade-groups by the grade.
5. After the splitting in (4), the student belongs to one of grade-groups. The c values in this grade-group are ranked. The improvement base b is defined as the upper quartile, with an exception that if a grade has a lower b value than the grade just lower than it (i.e. a lower grade has a higher b value), then the higher b value for the lower grade will be the b value for the higher grade as well.
6. The improvement score is defined as c divided by b, rounded to the nearest 1%.