

## TwoA Asset Use Case Description.

Document version: 1.2

Document date: 2017.07.17

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### TwoA ratings:

It is assumed that a game consists of one or more scenarios. A game designer has a freedom to decide what part of the game is designated as a single scenario, but it is assumed that the scenario has a learning content. Each scenario will have a quantitative difficulty rating in the TwoA asset. A higher rating will indicate higher difficulty that may demand higher skills from a player.

A player will also have a quantitative skill rating in the TwoA asset. A higher rating of a player will indicate higher skill. Player's skill rating can be updated after each scenario played by the player. If the player underperforms in a scenario then player's rating will decrease and increase otherwise. Player's skill rating will be estimated based on player's performance metrics. If the option for dynamic ratings for scenarios is enabled then difficulty ratings of a scenario will be recalculated after each playthrough. If the player underperforms in a scenario then scenario's rating will be increased. Scenario's rating will be decreased if the player performs better than expected.

1. A new player will be assigned a rating close to 0. The TwoA asset will automatically re-estimate this skill rating after each scenario played by the player.
2. Assigning quantitative difficulty ratings to scenarios can be done by one of following ways:
  - 2.1. Assign initial random ratings (e.g. 0) to scenarios and let the TwoA asset to adaptively estimate real difficulty ratings during gameplays with real players.
  - 2.2. Assign initial random ratings to scenarios and let the TwoA asset to adaptively estimate real difficulty ratings during a pre-test experiment with the human participant.
  - 2.3. Ratings are assigned by an experienced teacher (expert).
3. Setting difficulty ratings for scenarios to be either fixed or dynamic:
  - 3.1. Once set for scenarios, fixed ratings will not change (will not be re-estimated by the TwoA asset). This option is helpful if difficulty ratings of scenarios are well known and not expected to change.
  - 3.2. If ratings are dynamic then scenario's rating will be re-estimated after playthrough based on player's performance metrics. This option is helpful if scenario's difficulty is not known clearly. The TwoA asset will be able to estimate scenario's true difficulty rating after several playthroughs.

### Player's performance metrics:

Performance metrics indicate how well a player performed within a game scenario. The TwoA asset can accept one of two following performance metrics:

- A combination of response time and accuracy
- Accuracy only

*A combination of response time and accuracy:* Response time is an amount of time a player required to finish the scenario. The value of accuracy is 1 if the player was able to finish a scenario successfully and 0 otherwise. There are can be various ways to measure the accuracy: (1) overall outcome of all activities within a scenario are evaluated as 0 or 1; (2) not being able to finish the game within certain time threshold; (3) making more than a certain number of errors; (4) making more than a certain number of suboptimal decisions; etc.

*Accuracy only:* Accuracy can be any value between 0 and 1. For example, a value of 1 indicates a complete victory while 0 indicates a complete loss. A value of 0.5 can be used to indicate a draw.

#### **Use cases:**

1. The TwoA asset will track learning rate of students using a non-intrusive assessment based on player's performance metrics (for details see **Appendix 1**).
2. The TwoA asset can be used to identify possible learning content gaps in scenarios (for details see **Appendix 2**).
3. The TwoA asset will recommend a next scenario most suitable to the current skill level of the player.

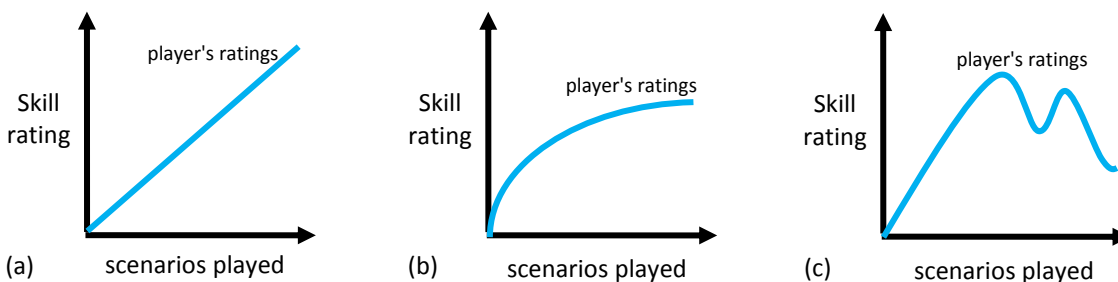
#### **Past uses of the assessment and adaptation algorithm in TwoA:**

TwoA asset is content agnostic meaning that it will NOT require any domain knowledge modeling effort. Therefore, it is ideal for assessing complex skills that are hard to express explicitly. It also makes the TwoA asset easy to reconfigure if new scenarios are added to the game. For examples of practical use of the assessment and adaptation algorithm used in the TwoA, you can refer to:

- <http://www.taalzee.nl/> (In Dutch) - Serious games for language skill practice; Taalzee provides detailed information about the strengths and weaknesses of players and their development compared to peers
- <http://www.statistiekfabriek.com/> (In Dutch) - Statistics Factory provides a fun environment for practicing statistics at their own level. The program contains more than 2000 statements about probability theory, descriptive and inferential statistics.
- <http://www.rekentuin.nl/> (In Dutch) (<http://www.mathsgarden.com/> in English) - Serious games for training various skills including mathematical reasoning, spatial reasoning, working memory capacity, logical reasoning.

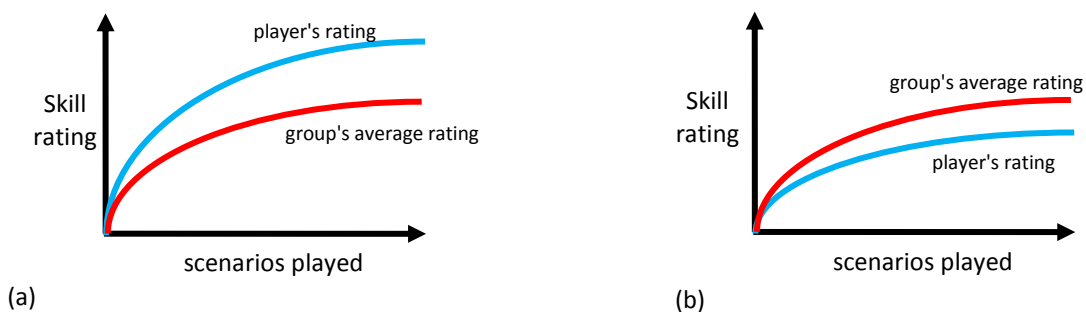
## Appendix 1

### 1. Identifying informative patterns in player's learning curve



Three examples of patterns that can be identified in player's skill ratings. (a) Player's learning at a steady rate. (b) Player's learning rate is slowing down due to a ceiling effect or barriers to learning. Some attention should be paid by the instructor. (c) Player's rating dropped after playing some scenarios. It is a clear indication that the player is underperforming in these scenarios. A teacher is advised to provide feedback.

### 2. Comparing player's learning curve compared to group average

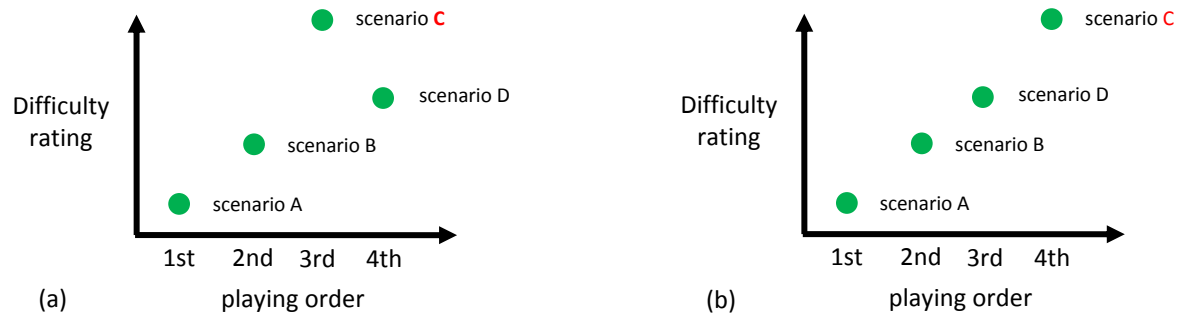


Two examples of player's skill rating compared to the group average. (a) Player's learning rate is above group average indicating that the player is a fast learner and performing quite well. (b) Player's learning rate is slow compared to group's average indicating that the player may have some learning difficulties and require feedback from a teacher.

## Appendix 2

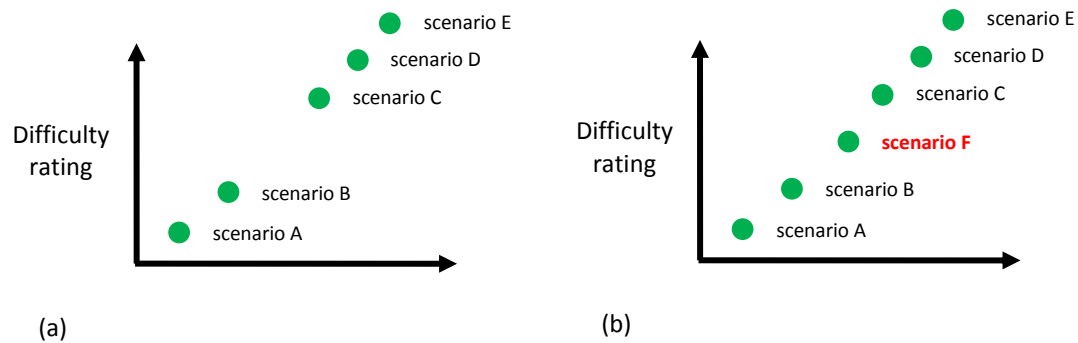
Using the difficulty ratings dynamically estimated by the TwoA asset, learning gaps and trends can be identified in scenarios.

### 1. Optimizing playing order of scenarios



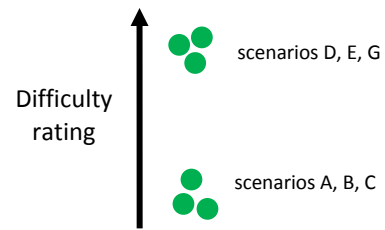
As shown in (a), players play four scenarios in the order of A, B, C and D. However, the higher rating of scenario C indicates that C is more difficult than the scenario D. Therefore, as shown in (b), changing the playing order of scenarios C and D may result in smoother learning experience for a player where the difficulty is increased gradually.

### 2. Identifying knowledge gaps in scenarios



In (a), the ratings for scenarios B and C are spaced from each more than the average spacing between other pairs of scenarios. This indicates there is a higher than expected jump in difficulty from B to C that might hinder a learning experience. In (b), introduction of scenario F makes spacing between modules the same contributing to a more gradual increase in difficulty.

### 3. Identifying clusters of similar scenarios



Based on similarity of their difficulty ratings, scenarios form two clusters. It is probable that scenarios in the same cluster involve same skills.