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1. What Does This Report Contain?

The section, 'Overview of the Product', provides a brief description of the product and its key features to give the context for the evaluation. The two sections following that present the findings from the evaluation. The Executive Summary provides the overall rating and offers implications in terms of benefits and limitations for teachers and learners. The Detailed Review section provides an in-depth evaluation of the product, categorized under three dimensions (or constructs) – Content Quality, Pedagogical Alignment, and Technology & Design. For each dimension, the product is reviewed on the criteria along with explanations for the rating, and grouped into clusters. Specific examples have been provided in this report to support and elaborate on the evaluation ratings.

The terms, ‘Exemplary’, ‘Valuable’, and ‘Potential to Improve’, used in the report refer to the rating scale for evaluating the product.

- **'Exemplary'** indicates that the product has been designed as per recommended learning theories and research-based evidence.
- **'Valuable'** indicates limited adherence of the product’s design to the recommended learning theories and research-based evidence.
- **'Potential to Improve'** indicates unsatisfactory or lack of adherence of the product’s design to the learning theories and research-based evidence.

2. Overview of the Product

Khan Academy offers instructional videos, practice exercises, and a personalized learning dashboard for learners to study at their pace in school or at home. The platform also has teacher tools and a ‘coach’ dashboard that empowers teachers to identify the learning requirements of each student, based on which they can tailor remediation for each student. The product contains elements of personalization and adaptivity for learners.
3. Executive Summary

Khan Academy | Mathematics | Grades 9-10

Content Quality
Exemplary

Pedagogical Alignment
Exemplary

Technology and Design
Exemplary

Overall, the product is aligned with national standards and includes excellent content and pedagogical strategies. This product is strong in adaptivity and might be very useful for learning and applying concepts in Mathematics for grades 9-10. The product might serve as an effective supplementary tool for teachers to support learners’ learning and monitor their progress.

Potential benefits of this product

Learners will likely be able to:

- Use the product as a supplementary resource as content is accurate and aligned with the NCERT curriculum
- Build understanding of key concepts as the quality of feedback and scaffolding is extensive
- Plan their learning process with the help of course challenges offered at the beginning that highlight their strengths and weaknesses in the topic
- Engage in the learning process as the product has a comprehensive set of motivational features and it follows a positive tone throughout
- Adopt the product easily due to its intuitive interface

Teachers will likely be able to:

- Integrate the product in their class to identify the learning needs of different students and support them
- Use the videos and practice exercises provided by this product in flipped classroom settings. This product may help integrate out-of-class and in-class learning.

Potential limitations of this product

- Face difficulty in understanding the accent and tone of the videos, especially learners from backgrounds that are not highly exposed to the English language in their day to day lives
- Feel disconnected from the content due to a lack of sufficient real-life context and scenarios.
- Experience difficulty building connections across multiple concepts due to the lack of experimentation, interactive activities, or mathematical tools for problem-solving.
# Executive Summary

## Summary of Review Ratings by Criteria

### Content Quality: Exemplary

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Content accuracy</td>
<td>⭐️⭐️⭐️⭐️</td>
</tr>
<tr>
<td>C2 Correctness and clarity in assessment</td>
<td>⭐️⭐️⭐️⭐️</td>
</tr>
<tr>
<td>C3 Language comprehensibility</td>
<td>⭐️⭐️⭐️</td>
</tr>
<tr>
<td>C4 Mathematics skill coverage</td>
<td>⭐️⭐️⭐️⭐️</td>
</tr>
<tr>
<td>C5 Curriculum alignment</td>
<td>⭐️⭐️⭐️⭐️</td>
</tr>
<tr>
<td>C6 Inclusivity in representation of learners</td>
<td>😞</td>
</tr>
</tbody>
</table>

### Pedagogical Alignment: Exemplary

<table>
<thead>
<tr>
<th>Pedagogical Element</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 Constructivist approach</td>
<td>😊</td>
</tr>
<tr>
<td>P2 Addressing learning gaps/ alternate conceptions</td>
<td>😊</td>
</tr>
<tr>
<td>P3 Content in context</td>
<td>😊</td>
</tr>
<tr>
<td>P4 Learner scaffolding</td>
<td>😊</td>
</tr>
<tr>
<td>P5 Cognitive engagement</td>
<td>😊</td>
</tr>
<tr>
<td>P6 Motivational Features</td>
<td>😊</td>
</tr>
</tbody>
</table>

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**Khan Academy (Grades 9-10): Summary of Review Ratings by Criteria**

**EdTech Tulna Evaluation Report: Khan Academy, Mathematics Grades 9-10, February 2021**

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### Technology and Design: Exemplary

**P7 Logical Chunking and Connectedness**  
The videos are small and are logically chunked to enhance understanding. Practice questions followed the videos.

**P8 Learning objective alignment**  
The learning objective and cognitive levels of the assessments are aligned to the content and the National curriculum.

**P9 Pedagogy – assessment method alignment**  
Pedagogical strategies and assessment are aligned as per NEP recommendations.

**P10 Cognitive levels covered**  
Questions and activities engaging learners in Higher Order Thinking Skills (HOTS) are insufficient.

**P11 Feedback Quality**  
Detailed explanations are present for assessment questions, and there is an opportunity to revisit the related content.

**P13 Adaptivity**  
The product is assessment adaptive, and the adaptivity is determined only based on learner performance.

**P14 Teacher support**  
Adequate teacher support is provided, where they can customize and assign students relevant material.

---

**T1 Interface design: Enable intuitive use**  
The interface is intuitive, all elements are clearly visible, and actions are mapped to their expected response.

**T2 Interface design: Assess consequences of an action**  
The interface provides an appropriate response to the learner’s action.

**T3 Learner navigation & pace**  
The interface provides complete control to learners over their learning path.

**T4 Universal Design**  
Features of universal design are present to ensure a low entry barrier to diverse learners.

**T5 Analytics for learners’ progress**  
The dashboard provides easily interpretable progress of the learners to both teachers and learners.

**T6 Tools to support problem solving**  
Except for the calculator, no other supporting tool is available in the product.

**T7 Meaningful interactivity**  
Appropriate interactivity like text inputs, drag and drop interfaces, radio buttons were used. No superfluous interactivity feature is present.

**T8 Content type - Technology alignment**  
Visualization type matched to the content type for some topics but there is a mismatch for some topics.
4. Detailed Review

4.1 Content Quality

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4.1 Content Quality

Content Quality measures the accuracy and content/skill coverage for the grade targeted and the specific domain. This dimension focuses on content accuracy and clarity, alignment to national standards, and inclusivity in content representations.

4.1.1 Content Accuracy and Clarity

**Content Accuracy (C1)** is rated Exemplary: The reviewers observed that all the content was accurate. The concepts and examples covered in the videos were realistic and correctly explained.

**Correctness and clarity in assessment (C2)** is rated Exemplary: For each unit, there was a unit test at the end that tested all concepts covered earlier. The assessment questions provided during practice and unit tests were also accurate and unambiguous. The solutions were correct, clear, and unambiguous, with clear explanations and steps provided.

**Language Comprehensibility (C3)** is rated Valuable: The language and vocabulary used in the videos and practice questions were simple and the sentences were short and easy to comprehend. But most videos used an American accent which might make it difficult for the intended learners to follow. In one or two videos, reviewers found that the Indian accent had been used.

**Illustrative example:** Learning Unit: Solution of linear equation, Grade 9

The steps to find the solution of the linear equation was explained in the video. The multiple-choice question was solved and the instructor explained the correct answer and why other choices were wrong (Fig.1).

**Illustrative example:** Topic: Introduction to Arithmetic Progressions', Grade 10

This example highlights one of the few instances where Indian accent had been used.
4.1.2 Alignment to National Standards

<table>
<thead>
<tr>
<th>Mathematics Skill coverage (C4)</th>
<th>Curriculum alignment (C5)</th>
</tr>
</thead>
</table>

Mathematics skill coverage (C4) and Curriculum alignment (C5) are rated Exemplary: Reviewers observed that most of the topics and sub-topics covered were aligned with the content present in NCERT textbooks for Grades 9-10. The chapter names and topics were aligned and similar to ones present in the NCERT textbook. The overall Mathematics mindset and skills required for grades 9-10 (recommended by NEP 2020 and NCF) such as developing notions of argumentation and proofs, experimentation and exploration, data analysis and interpretation, and integrating multiple concepts were covered in topics like Pythagoras Theorem, Circle, Arithmetic Progression, Trigonometry, Pairs of Linear Equations in two variables, Statistics, and Probability.

4.1.3 Inclusivity in Content Representation

| Inclusivity in the representation of learners (C6) |

Inclusivity in the representation of learners (C6) is rated Potential to Improve: Reviewers did not observe any specific or systematic effort in the product to include diversity in terms of gender, race, socio-economic class, religion, and looks, thus leading to a lack of representation of the relevant sections of society. Although there's diversity in terms of gender through names, these names weren’t inclusive as per the Indian context. As a result of such design choices, learners in India’s semi-urban and rural areas might be excluded or find it difficult to relate to the content. Furthermore, there was no specific focus or inclusion of minority groups particular to India or activities common to Indian households.

Illustrative example: Learning Unit: Probability, Grade 9

Non-Indian names like Gustavo, Greg, Sophia, Cam, Felipe, and Enzo along with references to non-Indian activities and games such as baseball, were frequently seen in the video and practice sessions.
"Gustavo is the league's home run leader. The probabilities for his total number of home runs for the season are as follows."
"Mekala has an MP3 player called the Jumble. The Jumble randomly selects a song for the user to listen to. Mekala's Jumble has 4 techno songs, 2 country songs, and 3 jazz songs on it. Complete the following statement with the best prediction. Mekala will listen to..."
Such examples will be difficult for Indian learners to understand.

Reviewers found many such examples which were not common or well known for the Indian audience.
4.2 Pedagogical Alignment

Pedagogical Alignment focuses on Adaptivity, learner-centered pedagogy, enhancing learner experience, assessment of learning, and teacher support. It measures the extent of alignment of the pedagogical strategies with national educational policies, Learning Sciences theories and design principles to create a meaningful learning experience.

4.2.1 Learner-Centred Approach

<table>
<thead>
<tr>
<th>Constructivist approach (P1)</th>
<th>Addressing learning gaps (P2)</th>
</tr>
</thead>
</table>

Constructivist approach in pedagogy design (P1) is rated Valuable: The product’s design provided few opportunities for learners to construct their understanding. But the team observed that there was inconsistency in the use of the constructivist approach. The learning unit consisted mainly of a set of videos with a few practice questions at the end. In most of the videos, the content is explained well. But only a few videos provide opportunities for the learner to interact and construct their own understanding of the topic.

Illustrative example: Topic: Similarity of Triangles, Grade 10

In the video, the instructor explained the concept of similarity between two triangles. He explained relation between sides and angles of similar triangles. There were three videos explaining the concepts of similarity, various tests of similarity and problem-solving based on similarity. Very few videos prompted and guided the learner to pause and reflect on the topic, preferring an information transmission model instead (Fig.2).

In a few videos, there were instances where the instructor asked the learner to pause and reflect and actually solved multiple examples while explaining the thought process behind the steps of the solution. However, majority of the questions present in the learning units were of the drill and practice type of questions.
Illustrative example: Topic: Similarity of Triangles, Grade 10

The questions were all similar and lacked diversity. There were no opportunities for the learners to experiment.

There were rare instances with opportunities for experimentation. One of them is mentioned below.

Illustrative example: Topic: Graphs of a Linear Equation, Grade 9

The drag and drop interactive feature of graphs likely helped the learners create their own understanding while practicing (Fig.3).

Fig.3. Learners are allowed to move the line up or down on the graph

Addressing learning gaps/ alternate conceptions (P2) is rated Exemplary: The common learning gaps had been identified as well as addressed very well in many topics. While explaining new topics or concepts, common misconceptions or learning gaps were often addressed in the videos.

Illustrative example: Topic: Similarity of Triangles, Grade 10

While determining the similarity of triangles, some examples were shown where it was impossible to determine the similarity (e.g., when measures of sides/angles aren’t given). The speaker also tried to display how it was different from congruent triangles, thus addressing a key misconception that learners have (Fig 4).
In this topic, the video explained how irrational numbers were different from rational numbers and took some special cases like the square root of two or the value of pi to highlight commonalities and differences between such numbers (Fig.5).

**Illustrative example: Topic: Irrational Numbers, Grade 9**

Fig.8 Congruence and similarity explained in the same worked out example

Fig.5. Video explaining difference between rational and irrational numbers

### 4.2.2. Enhancing learner experience

<table>
<thead>
<tr>
<th>Content in context (P3)</th>
<th>Learner scaffolding (P4)</th>
<th>Cognitive Engagement (P5)</th>
<th>Motivational Features (P6)</th>
<th>Logical Chunking and connectedness (P7)</th>
</tr>
</thead>
</table>

**Content in Context (P3) is rated Valuable:** Although most of the topics had some real-world context, it was inconsistent across the units. In some cases, the context was not relevant, whereas in some cases, it was not sufficient. In most topics, only 1-2 examples were provided but they were insufficient. The names, examples, and activities used to describe certain contexts were often not very suited for Indian learners, with the context being more relevant for American learners.
Illustrative example: Topic: Graphs of linear equation, Grade 9

In this unit, the video illustrated a problem where the learner was at the airport and had to change currency from Dollar to Euro. (Fig.6)

Illustrative example: Topic: Experimental Probability, Grade 9

In the video, the examples used were coin tosses and American football. Although the first example was relevant, the second one was not very relevant to the Indian context. Also, the context provided through the questions was not sufficient as there were few questions with context.

In some learning units, the context had been provided in terms of examples. Still, an introductory context required to help the learner appreciate the importance of studying the topic, was missing.

Illustrative example: Intro to Arithmetic Progression, Grade 10

In this unit, the video directly started looking at the relationship and pattern between numbers without explicitly calling out how it was observed in nature. Whereas, in NCERT, there was context provided at the beginning that covered how these progressions might look in daily life.

Learner Scaffolding (P4) is rated Exemplary: The product had scaffolds at multiple places. While explaining the concept, the instructor mostly started from the beginning and built on prior knowledge. All the steps were broken into small chunks appropriately. The questions were ordered from simple to complex in every learning unit. As the learning unit progressed, the topics built on previous ones. For example, almost every topic began with an introduction video that related to some prior foundational knowledge and ended with application questions like word problems. The complex topics were broken down into simple videos.

Illustrative example: Intro to Arithmetic Progression, Grade 10

The video started with simple examples of patterns and connected them to the concept of arithmetic progression. The next video explained how learners could find the next term in the sequence and developed a formula for calculating the nth term. Thus the entire unit was broken into small chunks, which simplified the learning task.

Illustrative example: Probability - a theoretical approach, Grade 10

In the unit, the instructor explained how in theory, the probability of coin tosses would be calculated, and then moved to rolling a die (which has more events). Then the next video focused on comparing how theoretical probability compared to actual experimental probability while picking up colored marbles from a jar. Such ordering of content will likely help the learner build on prior knowledge with each progressive step and form a correct mental model of the concept.
Illustrative example: Topic: Triangles, Grade 10

The unit was broken down into various topics scaffolded intuitively from introducing the concept of similarity, to solving problems on similarity, and then moving to the proofs and application of Pythagoras theorem. The topics were further chunked in smaller videos.

In the case of assessments, hints were present and scaffolded well, and remedial help was also provided. Some questions also had hints to help the learner reflect and solve the problem. When wrong or partially correct answer was given, the learner was prompted to try again, and also corrective measures like supplementary content was shown on doing it wrong once again. While solving the practice exercises, hints were scaffolded into multiple steps, and the learner could choose to see these steps one by one. All these scaffolding measures will likely help the learner in their learning process.

Illustrative example: Mean, Mode, Median, and Range, Grade 9

Hints are available along with the related content in the problem-solving process (Figs.7,8)

Stepwise hints were provided as learning scaffolds. Hints will likely enable learners to come out of an impasse during the problem-solving process (Fig.7).

Cognitive Engagement (P5) is rated Exemplary: The product had paid careful attention to engage the learners throughout their learning journey cognitively. Such engagement is ensured through the effective usage of verbal and visual cues. Cognitive engagement is exemplary for two main reasons:

Personalization using informal conversational style: The instructor always used an informal tone, often correcting some minor errors on the spot. These actions simulated a real classroom environment. There was an element of imperfection and authentic classroom setting that would allow learners to be engaged in the topic. Furthermore, the instructor asked the learner to pause and reflect, and try out the questions themselves. He used examples where he addressed the learner using first person "You are .." which makes it relatable and personal for the learner.
Effective use of signaling and highlighting: The presence of the chalk-board model mimics a real-life classroom setting as much as possible. The instructor used different colors and boxes for highlighting, made diagrams or structures to explain facts and concepts, and through the use of arrows or other appropriate representations, drew the learner’s attention to key elements. This level of signaling allowed the learner to focus on the right material and not get confused. Such signaling and highlighting had been done incredibly well throughout the grade range.

Motivational Features (P6) is rated Exemplary: The product did a great job targeting learners’ motivation and would help them stay engaged throughout the learning process. Reviewers found that the product had used various features such as the following.

**Energy points:** Learners could receive energy points for watching a video, completing it, or completing practice exercises.

**Mastery points:** Learners could receive mastery points for accurately finishing an exercise, a course challenge, or a unit test. These points are displayed if the learner has mastered the topic.

**Proficiency Levels:** A topic was categorized as familiar or proficient based on how well the learner had done with the practice exercises. These proficiency levels were also supplemented by messages like "Nice, ready to move on" or "Try again" or "Mastered."

**Recommendations:** A set of topics/videos were recommended to watch based on how the learner had performed across tests or challenges.

**Positive reinforcement:** The videos and practice exercises throughout the product followed a positive approach. For instance, an attractive sound played for every right answer. No sound was played if the answer was incorrect. Positive messages crafted were on the lines of "Keep trying, keep going," or "You’re almost there, you can do it." These messages could uplift the learner’s spirit and keep them engaged in the topic despite challenging questions.

**Badges:** The product had badges for the learner’s profile using celestial objects like the moon, earth, meteorite, along with tags such as "Nice Listener," and "Mad Scientist." While such badges may not be effective for everyone, they might be valuable for students who are motivated by rewards.
Logical chunking and connectedness (P7) is rated Exemplary: Khan Academy consisted of a set of multimedia (i.e., videos and questions) organized into distinct segments. The user interface had Learn (video content) and Practice (Assessments) sections parked side by side. Such a design would enable learners to assess themselves anytime while viewing the content. Hence, the videos were segmented at the sub-topic level. These segments were available as individual units and there was at least one assessment mapped to every sub-topic. At a course level, it was easy to navigate through an entire grade, where both chapters and topics were listed in the same order as per NCERT.

4.2.3 Assessment of Learning

<table>
<thead>
<tr>
<th>Learning objective - assessment alignment (P8)</th>
<th>Pedagogy-assessment method alignment (P9)</th>
<th>Cognitive levels covered (P10)</th>
<th>Feedback Quality (P11)</th>
</tr>
</thead>
</table>

Learning objective – assessment alignment (P8) is rated Exemplary: The learning objective was aligned to the content, and the assessments were aligned to the corresponding cognitive levels shown in the content.

Illustrative example: Introduction to trigonometric ratios, Grade 10

Learning objective: Learners would be able to find the trigonometric ratio for a given angle. The video explained the process of calculation of trigonometric ratios like sine, cosine, and tan.

![Fig.10.Assessment question](image)

Most of the learning objectives were implicit, for example, ‘determining similarity of triangles,’ ‘pairs of angles,’ ‘trigonometric ratios in right angles,’ and ‘arithmetic progressions word problems.’ Such implicit objectives indicated that the targeted cognitive level was not always mentioned explicitly, but rather self-understood via the name of the topic itself.

Pedagogy-assessment method alignment (P9) is rated Exemplary: The pedagogical strategy used in the product was as recommended for secondary grades in NEP, 2020. According to NEP, 2020 - some of the pedagogical strategies recommended for Secondary Stage (Grades 9-10) was injecting notions of argumentation and proofs, imbuing the spirit of experimentation and exploration and familiarizing students with characteristics of mathematical communication.
Illustrative example: Graphs of linear equation, Grade 9

There were some hands-on activities where the learner did have the opportunity to build graphs. During a video, the narrator often started with a scenario to introduce a concept, and there were enough places where pattern recognition as a skill was being imparted. For instance, in the practice problems, many non-examples were also given, which allowed the learner to differentiate the similarities and differences between applying a particular concept. This style of teaching suited this age group primarily because the learners at this age were better able to identify their areas of strengths and weaknesses and use this product to supplement specific topics or units, as needed. Also, the pedagogy and assessments used were aligned with the standard curriculum and board exams, where an example was shown using proper steps, and the assessment also showed multiple steps while explaining any solution (Fig. 11, 12, 13).

![Graphing a linear equation: y=2x+7](image)

Fig. 11. Worked out example using steps.

![Unit test](image)

Fig. 12. Assessment question with get help hint.

![Stepwise explanation of the solution](image)

Fig. 13. Stepwise explanation of the solution.
Cognitive levels covered (P10) is rated Valuable: There were questions present at various cognitive levels, ranging from understanding and identifying to application and estimation. HOTS were addressed through various basic, advanced, and challenging questions in case of Arithmetic Progressions and Quadratic Equations. Although an attempt was made to cover multiple Higher Order Thinking Skills (HOTS) questions, the coverage was insufficient. Most topics had only a few questions of certain types of HOTS from NCERT. For instance, in topics like Statistics, Applications of Trigonometry, Circles, Probability, and Surface Area and Volumes, there were very few questions and these did not cover many HOTS areas that were otherwise covered in the NCERT book. Even for broad topics like Circles, Probability, and Trigonometry, the number of questions per topic was restricted to only 3-5 questions, which were insufficient to cover the broad spectrum of HOTS skills.

Feedback Quality (P11) is rated Exemplary: The product had excellent feedback quality. This was showcased in various forms. The feedback provided for each question was comprehensively explained and was shown through multiple steps, breaking down a large solution into easily understandable chunks (Fig.14).

Illustrative example: Introduction to trigonometric ratios, Grade 10

The detailed stepwise solution is given as shown in Fig.14.

For each practice or assessment question, the corresponding remedial videos were also shown that were apt for the particular practice question. Such an arrangement would be helpful for the learners by enabling them to take corrective actions easily (Fig.15).
The feedback provided was always constructive and positive. In case all questions were answered incorrectly, the message was along the lines of "Keep practicing, you're almost there." Attractive sounds were only played when the learner answered correctly. Incorrect answers were not accompanied by any sound. All of this messaging and feedback likely helped the learners be more focused and helped them make the right decisions to correct their mistakes.

4.2.4. Adaptivity

Adaptivity (P13) is rated Valuable: The product showed content adaptivity to a limited extent governed by the learners' performance. There was no evidence of adaptivity based on learners' profiles or interactions. However, the product collected basic information such as grade and focus topics from the student and showed relevant content for that grade. There was an option of a diagnostic test - Course Challenge - that was available to the students but this was dependent completely on whether the learner chose to invoke it or not. Furthermore, the content or assessment questions did not change based on the result of this diagnostic test. However, the scores in the diagnostic test increased the learner's mastery points for specific topics and sub-topics.

Based on the results from the practice exercises and unit tests, the product nudged the learner to revisit certain topics by recommending videos to watch. Practice questions, videos, or the user interface did not change much based on individual learners and their responses. There was no evidence of adaptivity based on the learner's interaction with the system. For example, the product did not check or provide prompts if questions were answered at an unreasonable pace. Reviewers did not find the product adapting to user interaction patterns such as always selecting a particular option.

Thus, while there were some instances of adaptivity in the product, these were limited to the learners' performance in assessment questions.

4.2.5. Teacher Support

Teacher Support (P14) is rated Exemplary: Khan Academy offered ample affordances for supporting the teacher in the classroom. The product allowed teachers to make choices that influenced the students' learning path by creating a course mastery goal. For example, the teacher could set a goal for students to reach 90% mastery in a course by a certain date. Teachers could create their own classrooms and add the student roster. They could assign lessons and quizzes to the whole class as well as individual students. Thus, they could choose to encourage in-class practice of the content or treat them as homework, depending on their constraints. The teachers would be able to see student responses to each individual questions, assess areas of strength and weakness, and take appropriate actions.
4.3 Technology and Design

Technology & Design measures how well the technological affordances and the user interface design integrate with the pedagogy and context to promote a meaningful learning experience for all learners. The criteria in this dimension focus on user interface design and affordances that facilitate learning.

4.3.1 User Interface Design

Interface design: Enable intuitive use (T1) is rated Exemplary: The product was intuitive and all user events lead to the expected effect. All buttons were clearly visible, with text or other cues placed in meaningful locations on the screen. The interface followed a consistent pattern for all actions.

Illustrative example for showing consistency

All the grades and units were arranged similarly with the summary of the skill on the left side, list of videos and practice exercises on the right side, and buttons and texts having a consistent color scheme.

The interface also exploited natural mappings like play/pause buttons and vertical scrolling with expected outputs.

Interface design: Assess consequences of an action (T2) is rated Exemplary: The product provided appropriate feedback to each learner enabling them to rectify unintended actions easily.

Illustrative example for showing feedback on learner’s action

There was a ‘Start’ button given while starting a new topic and once the topic was completed text such as “Nice, Ready to move on” was displayed. Feedback provided during practice was easy to understand.

Illustrative example for showing error handling

For each correct answer, a button such as “Next question” was displayed. A button with the text “Try again” was displayed for a wrong answer. This also allowed for recovery from error and helped the learner attempt the incorrect questions once again.

If learners closed a window by mistake, they could start from the same unit after resuming the work.
Learner Navigation and pace (T3) is rated Exemplary: The product's interface design provided adequate control for learners over their learning path. Learners were able to navigate within and across the learning unit at the pace that they preferred. Learners could skip the videos or practice questions and move ahead to the next level. They could also revisit the content as per their requirement. Both backward and forward movements were allowed for the learners. Thus navigation and pace through content were based on the learner's requirement.

Universal Design (T4) is rated Exemplary: Several Web Content Accessibility Guidelines (WCAG) principles had been followed in the product. The product ensured low entry barriers for diverse learners with varying ability, special needs, or other characteristics. For example, content was presented in multiple ways using text, diagrams, and videos. Text alternative to non-text content (e.g., videos) was also provided in the form of subtitles in multiple languages. Assistive technology was able to recognize and read assessment questions. The content was allowed to appear and be operated in predictable ways. Non-keyboard alternatives for data input were supported. The accessibility options available in the user settings that enabled users to hide visually dependent content, reduce motion and animations, and remove color from videos were valuable additions.

4.3.2 Affordances that Facilitate Learning

<table>
<thead>
<tr>
<th>Analytics for learners’ progress (T5)</th>
<th>Tools to support problem-solving (T6)</th>
<th>Meaningful Interactivity (T7)</th>
<th>Content type – Technology alignment (T8)</th>
</tr>
</thead>
</table>

Analytics for learners’ progress (T5) is rated Exemplary: The product had a robust teacher’s dashboard which enabled them to assign assignments and tasks to students, check learners’ progress on the topics, and get an overall impression of the students' learning trajectory. Teachers could map each student’s learning path while checking their correct and incorrect responses. The student dashboard was designed comprehensively as well. It enabled each learner to review their progress on each activity by displaying the total problems answered, time spent on learning and exercises, and mastery levels.

Tools to support Problem-solving (T6) is rated Valuable: Reviewers found that the product contained mathematical tools such as calculators and scratch pads that could be used during problem-solving. However, topics such as Geometry lacked critical tools like protractors and rulers.
Meaningful Interactivity affordance of interface (T7) is rated Exemplary: The product had adequate basic interactivity features that were used appropriately to help the learner move forward with the learning in a meaningful manner. In the videos, there was an option to play, pause, forward, or rewind as per the learner’s need. Learners could also increase or decrease the speed of the video, as per their requirement. Assessments comprised a healthy mix of multiple choice questions, input boxes, and drag-drop features which enable meaningful learning.

Content type - Technology alignment (T8) is rated Valuable: The visualization mapped suitably to some content types. While factual concepts like the number line and abstract shapes were shown using appropriate diagrams, processes were explained using videos. However, simulations were missing for topics like surface areas and volumes and probability. For such topics, simulations could help explain related concepts effectively by representing them visually and thus help foster a deep conceptual understanding of the topic.
Appendix

How does the EdTech Tulna evaluation work?

FRAMEWORKS

EdTech Tulna frameworks define a set of standards for quality design of EdTech products. A rigorous and research backed process is established and applied for the creation of various nuanced frameworks. These frameworks are use-case specific to enable transparent and precise, high stakes decision making. The process includes considering existing research literature, feedback from the ground on multiple stakeholder needs and an appreciation for the quality of solutions currently supplied in the ecosystem.

The frameworks are categorized along the three dimensions of Content Quality, Pedagogical Alignment, and Technology & Design to capture a holistic view of the quality of the product design. The frameworks are also made available at varying levels of depth for varying stakeholder needs and range from supporting governments and institutions in making high stakes, rank based, adoption decisions, to providing a brief overview of the key criteria to be considered while designing a product.

TOOLS

Each Tulna framework is accompanied by a toolkit that is specifically designed to guide experts to evaluate EdTech products. These toolkits are customized to the type of EdTech solution, grades, subjects, to drive meaningful and nuanced evaluations. The tools are informed by research as well as iterative empirical study and tested for inter-rater reliability and validity. A typical toolkit consists of rubrics and reviewer guidelines to enable evaluators to interpret the framework and conduct unbiased evaluations. Each criterion within the framework is rated along a three-point rating scale - ‘Exemplary’, ‘Valuable’, and ‘Potential to Improve’ - indicating the level of alignment with expectations laid out in the framework. Toolkits include supporting materials - videos, templates, and example illustrations - to guide experts while conducting evaluations.

PROCESS

Each product goes through a rigorous review process that takes approximately 160 hours for four grade ranges K-2, 3-5, 6-8, and 9-10. Each review team is designed to be independent and neutral. A typical expert review team consists of 3-4 members who are subject matter experts, instructional designers, user-interaction experts, user-experience design experts, and professionals with experience in teaching and implementing EdTech in field settings. Each review team has an anchor of at least one experienced evaluator.

Each member of the expert review team undertakes a two-week long intensive training on understanding the frameworks and the subsequent application of its toolkits to conduct evaluations. For each product, the review team applies a systematic sampling strategy and decides the representative learning units that will be reviewed. The team collectively reviews a subset of the learning units to check for convergence and establish inter-rater reliability. Team members then individually review the remaining learning units. The team finally meets to synthesize key points and takeaways of each review and elaborates their reviews into an in-depth report, which is overseen by the experienced evaluator.

The role of the product company is limited to an initial demo which supports the review team to deepen their appreciation of the intended use of the product, and its scope. The product company is then provided the final reviews and their unedited responses are published alongside the expert evaluations on the Tulna evaluation center.