# Supporting science teachers to select quality edtech learning solutions for their context

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**Abstract:** There has been a surge in the development and use of education technology (edtech) learning solutions in the past decade. Amidst the pandemic, teachers were compelled to incorporate edtech into their instructional approaches. While there are several frameworks, standards, or guidelines available for implementing these edtech solutions, few address the problem of selecting good quality edtech solutions. The ones that address the problem of quality edtech solutions fail to cover all criteria that are needed for effective edtech solutions. In addition, they are not easily usable by the teachers for the selection of an edtech solution. For an edtech solution to be effective it is crucial that it aligns with the context of the learner such as their grade range, their subject of interest, language comprehensibility, etc. Also we found that there are no standards that are available specifically for science teachers in the Indian context. In this paper, we present a validated, reliable, and research-based, Edtech Tulna Index designed to support science teachers in India to select quality edtech learning solutions for their classrooms. We conducted a study to understand the challenges that teachers face and to test the usability of the tulna index and its usefulness to mitigate teachers' challenges pertaining to the selection of edtech. We found that teachers found the tulna index easy to use. This paper contributes to the research of evaluation of edtech solutions by listing the criteria required for science teachers to select the edtech product, while it also provides the practice community with a usable tool that can be used to select effective learning solutions and potentially enhance their teaching-learning.
**Keywords:** EdTech, TULNA, guideline, evaluation, useability, perception

## 1. Introduction

The availability and variety of edtech learning solutions are growing exponentially worldwide. Post-Covid the demand for these edtech solutions is shown to be on the rise and so is the influx of learning solutions into the market (Burns, 2021). The variety in the solutions is brought about not only by the numerous subjects offered, the language of instruction, and age groups but also by different settings in which instruction takes place. Under such circumstances, it is challenging for users (students/ parents/ teachers/ institutions) to choose an effective learning solution (Patel et. al., 2021), i.e. one that contributes to a meaningful learning experience. What is required is a set of guidelines that is easily usable by teachers for identifying and selecting relevant and good-quality edtech solutions. In the absence of such standards or guidelines, the selection will depend on individual teachers' understanding and perspective of 'What is a good quality learning solution for science?' For some, it could be good graphics or 3D animation, while others might feel experimentation or activities are more relevant. This leads to variability and lack of a common understanding of what constitutes 'good quality'. Often users rely on reviews by previous users and market reviews to guide them in the selection process. Such ad hoc decision-making will lead to selection of an ineffective learning solution that might not best suit their requirement.

Globally there exist some standards and frameworks to evaluate the quality of digital learning solutions. However, these cannot be adopted universally as learning is known to be context-dependent (Bransford et. al., 2000). This paper reports the design and development of a research-based, easily usable, context-specific, “**Edtech Tulna**” index to support teachers in the selection of a good quality edtech learning solution for their use in the science classroom. A study was undertaken with science teachers currently teaching grades 6-10 in India, to explore their perceptions of the index's usefulness and usability.

## 2. Literature Review

There are several frameworks and standards that provide guidelines and structures to teachers for effective teaching with ICT. Among these ISTE provides guiding principles for the selection of edtech (ISTE, 2000). CENTA standards (CENTA, 2023) are used for training teachers to use the ICT tools to communicate, create, disseminate, store, and manage information and are aligned with National Professional Standards for Teachers under India’s National Education Policy 2020 (NEP, 2020) guidelines. The Central Institute of Educational Technology (CIET, 2023) provides an e-content evaluation tool and an assessment tool for digital media. Similarly, the recently released Pragyata guidelines for adopting ICT and digital education (Pragyata, 2023) support infrastructure assessment, teacher training, cyber safety and privacy, teacher professional development, physical and mental well-being of students, and a few pedagogical strategies for using ICT. Many of these frameworks focus on effective implementation of ICT and those that focus on the quality of edtech learning solutions do not contain detailed guidelines. Hence the onus is on the teacher to apply the criteria to their subject and context.

During the Covid-19 pandemic teachers were compelled to change their instructional approaches to include digital resources or edtech. There are theoretical frameworks, like UTAUT2(Venkatesh et. al., 2012), that are developed to understand different aspects of the adoption of technology-based products. In Indian classrooms, the integration of edtech is mainly in the hands of the teacher. According to Bharat Survey for Edtech (2023) Report, about 1 in 3 of 9867 school children received teacher-directed materials through various digital mediums. The context of the learner, the teaching style or method of teaching adopted by the teacher for a particular grade range, the subject being taught, and language comprehensibility are important points to be considered while adopting edtech solutions (Soundararaj et.al., 2022). A study for developing a conceptual framework for evaluating web-based learning resources (WBLR) for school education found the influence of culture on the choice of WBLR among students (Hadjerrouit, 2010). Such studies underscore the need for a framework that considers the context in which the learning is taking place.

Few discipline-specific standards for science such as Next Generation Science Standards (NGSS, 2023) and Common Core Science Standards (2010) are available, however, they are mostly developed in the United States and fail to include the context of learners from other countries. To overcome this problem, countries such as Australia and the UK have come up with their own standards to be incorporated into their curriculum. Since teachers have a good understanding of the context of their learners, it is important to equip teachers with a framework that they can adopt for finding good quality edtech learning solutions for their context. Our research aims at providing this to the teachers in the form of an index called Edtech Tulna (2023) that contains detailed guidelines for teachers in India for selecting science edtech learning solutions in their context.

## 3. Design of *Edtech Tulna* Index

We created the Edtech Tulna index as a comprehensive and user-friendly tool for systematically identifying high-quality science edtech learning solutions. Our index is informed by (i) literature from learning theories, multimedia learning, Human-Computer interaction, existing edtech evaluation models, and disciplinary teaching-learning practices in the science domain, (ii) the Indian govt. policies and educational standards and (iii) insights from the product landscape in the Indian edtech ecosystem (Figure 1). The Tulna index is a rubric covering three constructs: Content Quality, Pedagogical Alignment, and Technology and Design (Edtech Tulna, 2023).

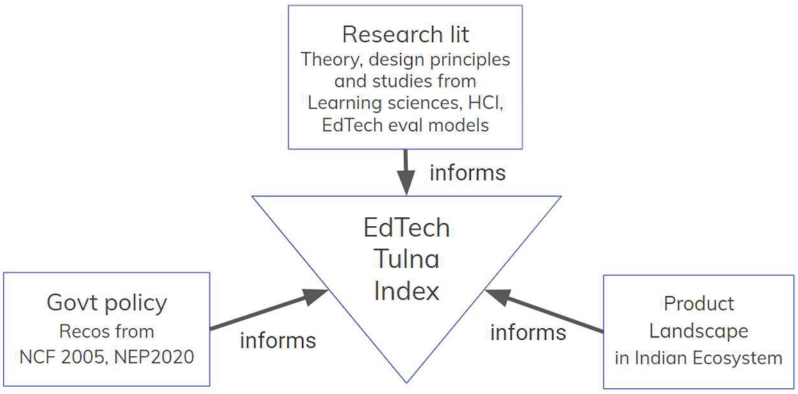


*Figure 1. Basis of Edtech Tulna Science Evaluation Index.*

### *3.1 Theoretical Basis for Criteria*

Seminal papers with theories related to teaching and learning in the science domain and multimedia learning were used to finalize the twelve criteria in the Tulna Index. The most important criterion for evaluating the content quality of any educational material is the accuracy of the content. Also in science, it is important that the content is up-to-date with recent happenings (eg. pandemic, etc.) and scientific advancements (NGSS Lead States, 2013). The voice-over and captions used in the content have to be comprehensible by the targeted group of learners for ease of learning (Mayer, 2014; Soundararaj et.al., 2022). Alignment with national standards like the National Council of Educational Research and Training(NCERT)) and coverage of skills recommended by the government guidelines such as NCF(2005) and NEP(2020), in an Indian context, is also crucial. When designing educational content, it's crucial to reflect the learner's local context and ensure inclusive representation in terms of race, gender, religion, and socio-economic backgrounds. This must be achieved while avoiding stereotypes, allowing learners to identify with the content (Dore, 2022).

Table 1. *Tulna criteria under each construct*

| Construct (no. of criteria) | Criteria Name |
|---|---|
| **Content Quality (4)** | Content accuracy & clarity, Language comprehensibility, Alignment to national standards, Inclusivity |
| **Pedagogical Alignment (6)** | Content in Context, Learner Scaffolding. Cognitive Engagement, Logical chunking and connectedness, Feedback Quality, Teacher Support |
| **Technology and Design (2)** | Interface Design. Universal Design |

Pedagogy for science must include authentic and meaningful scenarios from the local surroundings like the learner’s home, neighborhood, community, and/or culture, that reflect the practice of science (NGSS Lead States, 2013). Support and assistance should be provided to bridge the gap between a learner’s current abilities (actual development) and their potential abilities (zone of proximal development) to accomplish tasks more complex than they could do alone (Quintana et.al., 2004; Vygotsky & Cole, 1978). To promote engagement the content should be conversational and visually guided (Mayer, 2014; Van Gog, 2014). Breaking the content into small meaningful segments arranged in logical sequence can enhance learning (Mayer & Pilegard, 2014). Good feedback strengthens the students’ capacity to self-regulate their own performance (Nicol & Macfarlane-Dick, 2006). In addition, instructors need support to integrate Edtech learning solutions into their teaching effectively (Banerjee & Murthy, 2012).

Any technology-based solution should have an easy-to-use and intuitive interface (Davis, 1989). Furthermore, the learning solutions should be designed to be accessible to diverse learners in order to provide equal access and equal opportunity to people with diverse abilities (Caldwell et. al., 2008). Based on the literature review and national standards, the final criteria included in the Tulna index are summarized in Table 1.

### *3.2 Structure of the Index*

Each criterion in the Tulna Index has easy-to-understand yet detailed reviewer guidelines to help teachers score on a 3 pt-scale of *Not-at-all Incorporated*, *Partially Incorporated*, and *Fully Incorporated*. The reviewer guidelines were developed based on literature and an examination of multiple science edtech solutions for grades 6-8 and 9-10 in the Indian edtech landscape. Insights from exploring existing solutions were utilized to create authentic examples for each criterion. Table 2 gives a glimpse of the index using one criterion from each of the three constructs.

Table 2. *Sample criteria and reviewer guidelines from the Tulna Index*

| Criteria | Reviewer Guidelines |
|---|---|
| **Language Compreh -ensibility** | **Is the language appropriate for the intended learners?**<br>- The vocabulary and accent used is familiar to the learners of the particular grade range.<br>- The sentences spoken or those appearing on-screen are short and easy to follow.<br>- The introduction of scientific terms has to be done in a grade-appropriate manner.<br>*e.g. Use of s,p,d,f orbitals to teach covalent bonds in grade 10 is not recommended as the orbitals are not introduced until that grade.*<br>- There is no use of slangs or informal language [e.g., gonna, wanna, gotcha] that the learners find difficult to follow |
| **Content in Context** | **Does the content incorporate appropriate real-life context?**<br>- The context provided is relevant to the context of the learner wherever required<br>- The context provided is sufficient for the learner to master the specific skill<br>- The context does not contain scenarios involving violence, combat, gambling or stereotyping<br>- The product provides opportunities to see the application of the skill in the lives of the learners<br>*e.g. to explain the concept of magnetism, showing that a magnet attracts iron nails is relevant but not sufficient, whereas showing that a magnet can be used to separate recyclable iron particles from other wastes in a junkyard is a relevant and sufficient context.* |
| **Universal Design** | **Is the product accessible to diverse learners?**<br>There are multiple ways to make the product accessible to learners with diverse needs.<br>- Audio-only or video-only media provides a transcript and/ or on screen text/ caption.<br>- Text-only media has a voice-over matching with the text.<br>- Provide captions for all prerecorded / live audio (with or without video) content.<br>- Possibility of recording an answer and hearing assessment questions as voice-overs.<br>- Make it easier for users to see and hear content (*e.g., an option to increase font size*) |

For a particular learning solution if the teacher finds that all the indicators mentioned in the reviewer guidelines are met the learning solution "*fully incorporates*" the criteria. The learning solution "*partially incorporates*" the criteria, if only some of the indicators are met or if all the indicators are met but are present inconsistently in the learning solution. And if none or very few of the indicators are met then the learning solution "*not-at-all incorporates*" the criteria.

### *3.3 Validity and Reliability of Tulna Index*

The Face and Content Validity of the Tulna index was established through a rigorous process involving expert review. Individual assessments from the experts comprising a senior faculty, an edtech expert, and SME were incorporated to arrive at the final index. The interrater reliability was established in 2 stages: (i) during the development of the index and, (ii) after completion of the index. During development, the interrater was conducted among the 3 researchers who were involved in the design of the index. Each researcher assessed 2 learning solutions, yielding an average Cohen's kappa of 0.335 across the 12 criteria. After this, the researchers discussed their rationale for the assigned scores. Based on the discussion, some modifications to the wording were done and a few more explanations and examples were added to remove subjectivity. After revision, the same team evaluated 2 new learning solutions and the average value of the kappa statistic improved to 0.704, which is considered to be a "fair" agreement (Jonsson & Svingby, 2007). In the second stage, two novice evaluators were trained on the index and they along with a researcher evaluated 4 learning solutions individually. The average value of the kappa statistic between the novice evaluators and the researcher was 0.708, replicating the result observed with the research team thereby establishing the reliability of our index.

## 4. Study Method

To understand the perceived usefulness, usability, and relevance of the Tulna index we conducted a study with science teachers. The research questions for the study were as follows:

1. Is the Tulna index useful for teachers for selecting edtech learning solutions? How can the teachers adopt it for their use?
2. Do teachers find the Tulna index usable?

### *4.1 Participants*

For purposive sampling, we approached science teachers through social media forums of school teachers, publicizing our study as Edtech Tulna- Sensitization Workshop to aid selection of good quality science edtech learning solutions for their classrooms. The teachers that registered for the workshop were from either government or government-aided schools catering to medium to low-income groups in urban and semi-urban areas in India. Most of the teachers had some experience in using edtech while the number of years of experience varied. A few teachers from non-science domains also registered but their data was not considered for the analysis.

### *4.2 Procedure*

Post registration, the teachers attended a 3hr workshop where they were introduced to the Tulna index, and the 12 criteria were explained in detail with appropriate examples. The workshop was made interactive with several interspersed activities to invite participation from the attendees. Figure 2 shows one of the activities from the workshop.

### *4.3 Data collection and analysis*

To answer the RQs of the study, we employed several data collection instruments and analyzed them using mixed methods (Creswell & Poth, 2016). To get insights into teachers' backgrounds and perceptions of using edtech in the classroom, we asked the teachers to fill out an online questionnaire during registration. The questionnaire included questions like "According to you what features contribute to good quality content in an edtech learning solution?", etc.

To understand the *perceived usefulness* of our index, we conducted semi-structured interviews with interested participants. Perceived usefulness is known to be influenced by culture (Straub et. al., 1997) and it is highly unlikely to be captured through surveys like TAM (Davis, 1989). A few of the questions asked in the interview were, "Did your idea about evaluating the quality of edtech learning solutions change in any way after the workshop?” and “How does Tulna help you overcome the challenges you face while selecting edtech learning solutions?”. The interviews were recorded and transcribed, which were later analyzed using the principles of content analysis (Mayring, 2015).

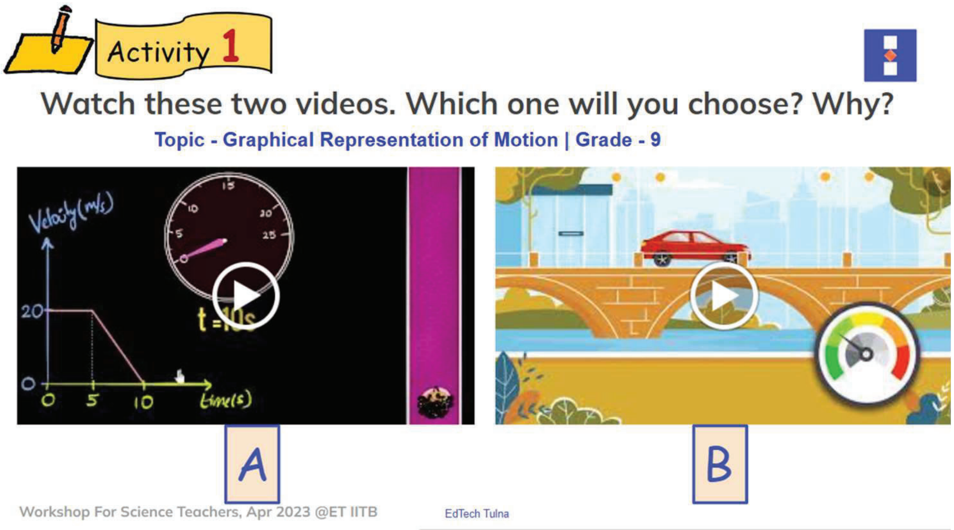


*Figure 2. Sample activity from the workshop on choosing an edtech learning solution*

To gauge the Tulna index's *usability*, we had teachers complete the System Usability Scale (Brooke, 1996) post-workshop. SUS is a robust and versatile tool that can be applied to a wide range of ‘products’ (Bangor et. al., 2008). The participants answered the SUS survey containing 10 items on a 5-point Likert scale ranging from strongly disagree to strongly agree. The survey includes both positive and negative questions like - “I thought the Tulna index was easy to use.” and “I think that I would need the support of a technical person to be able to use the Tulna index.”.

## 5. Findings

### *5.1 Demographics and background of teachers*

A total of 27 educators enrolled in the workshop, with teaching experience spanning from 1 to 30 years. The majority of these instructors were involved in teaching science to students in grades 6 to 8, as well as grades 9 to 10. About 74% (20 teachers) had some experience using edtech learning solutions, such as Audio-Video content, assessments, simulations, and experiments. All the teachers agreed that using Edtech learning solutions was beneficial for the students. When asked to articulate the benefits of using edtech in the classroom, the majority of teachers mentioned that *edtech helps in visualization and increases the efficiency of teaching-learning*.

Based on responses provided regarding the challenges in *selecting edtech learning solutions* it was observed that teachers encounter difficulty in finding content for their educational context. A few responses were “Language that is used by majority of the videos is quite not in sync with the demographics that we support”; “The explanation style or presentation style in the available AV are different from my style, that the children are used to for several years.”. In addition, the complexity of selecting a single learning resource amidst an array of options was a concern. The teachers mentioned “I can't choose the source for a particular topic”, and “Selection is not easy as it is not between A or B. Youtube has a lot of videos on the same topic, several channels, etc.”. *Spontaneous edtech selection* was evident from responses such as “it is time-consuming to check all the content, maybe the first 5 minutes is best but later it is difficult.” and “I select by searching with Google or collecting from friends”.

Table 3. *Frequency analysis of quality indicators of edtech (reporting indicators mentioned by at least 4 teachers)*

| Quality indicators | freq. | Quality indicators | freq. |
|---|---|---|---|
| assessment questions | 14 | integration with other tools | 7 |
| activity and experimentation based | 10 | gamification | 6 |
| daily-life context | 10 | user friendly | 6 |
| visualization | 9 | interesting | 4 |
| easy to understand | 8 | scalable | 4 |
| build on previous learning | 7 | curriculum | 4 |

Table 3 shows the frequency analysis of the teachers' responses to “According to you, what features contribute to a good quality edtech learning solution?”. Given that the teachers provided textual answers, their responses were categorized into distinct "quality indicators” in edtech solutions. It is noteworthy that almost no teacher (n<4) mentioned indicators like supporting learning materials, teacher support, short videos, and up-to-date scientific information.

## *5.2 Usefulness*

To gain insight into the usefulness of our Tulna index we conducted semi-structured interviews with 8 out of 16 teachers who attended the workshop. In response to whether the Tulna index aids in selecting appropriate edtech learning solutions, 5 teachers strongly agreed, and 3 agreed on a 5-point Likert scale. One of the teachers said that “Yes, using Tulna criteria gives me faith that I will select the right solutions because when I am reviewing to choose a product it is my perspective or maybe 1-2 teachers but with Tulna tool is made address to a particular solution.” Additionally, teachers were asked about the significance of each of the 12 criteria in selecting edtech learning solutions. Their response was recorded using a 5-point Likert scale ranging from Strongly Disagree to Strongly Agree. The outcomes are consolidated in Table 4.

One of the questions that were asked to teachers was “*How would you use the Tulna index?*”, we found the responses to be very insightful. One of the teachers said that “by understanding criteria such as logical chunking and connectedness, content in context and alignment to national standards, I found the process to make my teaching effective” (translated from Hindi). We also observed a change in the teachers' perception regarding the quality of edtech learning solutions. When asked the question “*After the workshop, has your idea about the quality of edtech learning solutions changed in any way?*”, most agreed, and four of the teachers elaborated. One of the teachers said “I can choose the content for my demographics that fits Tulna criteria, focused attention to the particular parameters, and be more mindful while I do my own review.” another teacher said “Yes, I will remember to check for the criterias discussed. Also, I will use the same criteria for video creation. Content accuracy and clarity and proper language are main for any content, logical connections and length of the content to be only 5 to 10 mins for discussing a single concept is very useful. It is useful. Yes, Tulna is useful”. One teacher said “If I follow Tulna criteria then we will get a good outcome… can expect better responses from students. Pedagogy changes with grade but children might get tired of my teaching style so videos will be useful to use in teaching”, while another teacher said “Content if not related to what is not being taught can harmful for children…in point of view of examination the content has to be aligned to national standards. The examples should be given in the context of the child’s learning environment… support should be given in the context of child’s mental ability, long videos should be avoided…”

When asked if *“any criteria that you did not check before. But now, after the workshop, you realize that there's something more that you should look for?”,* one of the teachers mentioned that “I will check for content accuracy throughout the entire duration, earlier we used to look for initial few mins… full video must be watched”. Another teacher said that "There's a difference between the content and the context. So how I can, you know, this is what will be content in the context, making them before making any lesson plan."

Table 4. *Avg. score of relevance for each criterion on 5-pt Likert Scale (n=8).*

| Construct | Criteria | Avg. score |
|---|---|---|
| Content Quality | Content accuracy & clarity | 4.625 |
| | Language comprehensibility | 4.875 |
| | Alignment to national standards | 4.625 |
| | Inclusivity | 4.125 |
| Pedagogical Alignment | Content in Context | 4.750 |
| | Learner Scaffolding | 4.500 |
| | Cognitive Engagement | 4.250 |
| | Logical chunking and connectedness | 4.500 |
| | Feedback Quality | 4.500 |
| | Teacher Support | 4.625 |
| Technology and Design | Interface Design | 4.625 |
| | Universal Design | 4.250 |

### *5.2 Usability*

The Tulna index's usability was confirmed by 8 participant teachers who completed the System Usability Survey during post-workshop interviews.The SUS score of the Tulna index was found to be 71.563, which corresponds to a “good” usability score (Brooke, 1996). The SUS score can be decomposed into usability and learnability (Lewis & Sauro, 2009). The Tulna index scored high on usability (92.969), while it scored poorly on learnability (48.438). Items 4 and 10 measure learnability with statements: “I think I would need the support of a technical person to be able to use this system.” and “I needed to learn a lot of things before I could get going with this system.”. Low scores on these two items emphasize the need for Tulna index training.

## 6. Discussion and Conclusion

To address RQ1, we conclude that teachers found the Tulna index useful, as evidenced by their responses to the Likert scale questions as well as open-ended questions. Teachers stated that they will likely use Tulna in their future practice to identify an edtech product suitable for their needs, thereby making their practice effective. This aligns with prior research which has emphasized the need and importance of contextualization in edtech (Specht, 2006). Teachers also repurposed the Tulna criteria and stated that they will use them as quality criteria during their video creation process. Teachers’ responses were highly reflective and illustrated examples of *reflection-on-action* (Schon, 1983). We noticed a shift in teachers’ decision-making process from an ad hoc selection approach to a more structured and nuanced one, wherein they applied specific research-based criteria to make a judgment. Teachers also reflected on changes in their own practice, such as viewing content more deeply before making selection decisions. With regard to RQ2, teachers found the Tulna index highly usable, which indicates a high potential for actual use in practice (Pan et. al., 2020). Overall, teachers perceived the value of a common set of quality standards for edtech selection rather than varied individual perceptions.

The Covid -19 pandemic has forced educators to adopt and integrate edtech learning solutions into their teaching practices. The lack of appropriate scaffolds complicates the adoption of good quality edtech solutions. Our study introduces a research-based and context-specific Edtech Tulna index, offering teachers a reliable and user-friendly tool to choose high-quality edtech learning solutions for their classrooms. This study involving science teachers also investigates the shift in their perception of edtech learning solutions following awareness about the Tulna index. Additionally, the study evaluates the Tulna index's usefulness and usability.

Research has established a positive correlation between teachers' perceptions of the beneficial impact of technology and the actual utilization of technology in classrooms (Domingo & Garganté, 2016) but what is missing is context-specific guidelines that would help the teachers to choose relevant quality content for their teaching practices. Available frameworks and standards address the evaluation or implementation of edtech solutions, an index to solve the selection problem of edtech solutions specifically in science education is missing. The Tulna index bridges this gap by providing selection guidelines.

The limitations of our study include the sampling process wherein only the teachers who were already interested in using edtech volunteered and hence our findings could not capture the changes in the perception of teachers who are not inclined to use edtech. Another limitation was that the teachers were mostly from urban and semi-urban schools. It would be beneficial to scale up the study and understand the perspective of teachers from rural India.

The science-specific Tulna index with detailed guidelines on what indicators to check in a learning solution is not only a valuable contribution to addressing the selection challenge faced by teachers but will also give a starting point to the researchers to further explore this area of providing teachers with support for edtech adoption.

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