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Research Article

Educating non-specialized audiences about seismic design principles using videos and physical models

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Abstract: The prevalence of self-construction practices in Türkiye has resulted in a building stock whose earthquake resilience is highly uncertain. To mitigate the potentially devastating impact of anticipated large earthquakes, one viable approach is to increase earthquake awareness among builders themselves. However, these builders lack formal engineering training and are ordinary citizens. Therefore, the challenge lies in devising visual teaching methods, such as short videos, to explain complex seismic phenomena in a comprehensible manner. This paper introduces the use of educational media tailored for non-specialized audiences, encompassing regular citizens and students without engineering backgrounds. These videos are based on experiments conducted with physical models on a homemade shake table. They focus on key factors influencing the seismic response of multi-storey buildings and highlight common design and construction errors that lead to building damage. To assess the effectiveness of this approach, we conducted a workshop with junior architecture students, followed by post-workshop qualitative assessments through knowledge surveys and interviews. The findings indicate that while single-topic videos were effective learning tools for students without prior knowledge of seismic building design, students found models particularly useful for explaining specific concepts such as torsional behavior, the role of diaphragms, and the performance of non-structural components. However, despite positive feedback on the effectiveness of model testing, students generally did not perceive significant knowledge acquisition in model construction. Ultimately, the accessibility of freely available videos, coupled with their enhanced educational value, makes them effective tools for raising seismic awareness in communities vulnerable to future earthquakes.

1. INTRODUCTION

Due to widespread self-construction practices in Türkiye over recent decades, the actual earthquake resistance of existing buildings is uncertain (Dener, 1994; Green, 2008; Iban, 2020). Unfortunately, these practices often result in a lack of compliance with building codes, which has been a major contributor to widespread building damage in both past and recent earthquakes in Türkiye (Binici et al., 2022; Hussain et al., 2023; Yakut et al., 2022). Considering that a

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significant portion of the building stock does not comply with codes, extensive damage is expected when moderate-to-large earthquakes strike urban areas in the near future.

The current high vulnerability of Türkiye's building stock has prompted calls for immediate action to mitigate seismic risk, such as assessing existing buildings. However, due to the large number of housing units in Türkiye, this cannot be achieved immediately but only with a small number of buildings (Binici et al., 2022). Long-term measures to prevent substandard construction practices in the future include implementing a system to prosecute negligent builders and establishing compulsory registration for builders and contractors. Yet, given the long-term nature of the self-construction problem and its complex interplay with social and economic factors, a more effective solution may be focusing efforts on empowering self-builders to actively reduce cities' vulnerability to natural disasters (Green, 2008). Achieving this requires educating citizens, both current and future, on the key aspects of building seismic behavior.

1.1. Educating Non-Specialized Audiences in Earthquake-Resistant Design of Buildings

Education in seismic-resistant construction for self-builders would prioritize individual action in hazard prevention. This entails simplifying current seismic codes, which can be complex for non-specialists but have been shown to significantly reduce earthquake-related disasters (Spence, 2004). By expanding residents' knowledge of seismic design and construction techniques, they will not only be aware of their homes' vulnerability but also understand how to mitigate it (Green, 2008). Importantly, such education can demonstrate to self-builders that using proper reinforcement detailing and concrete ratios can enhance a structure's seismic resistance without significantly increasing material costs (Green, 2008). Furthermore, education can deter the proliferation of *quick and cheap* construction approaches, where uneducated constructors prioritize selling apartments quickly with ostentatious but inexpensive materials (Dener, 1994).

This paper suggests using educational videos to impart knowledge about building seismic behavior to non-specialized audiences. These videos aim to bridge the gap between professional engineering knowledge and regular citizens, some of whom may consider building their own homes. Originally intended for self-builders, including models in the videos introduces a pedagogical dimension suitable for educational environments like schools and universities. Thus, the term "non-specialized audience" expands to encompass all students. This expansion aligns with calls for earthquake education programs to be integrated into school and community curricula, thereby enhancing ordinary citizens' disaster awareness (Simonacci & Gallo, 2017).

The purpose of this paper is to evaluate the effectiveness of these educational media as both a learning tool and in raising seismic awareness, through qualitative assessments conducted with university students. The selected cohort, a second-year architecture class with no prior seismic design knowledge, provides a controlled environment to evaluate the validity of the learning method and the strategies that enhance its effectiveness.

2. METHODS

2.1. Development of Educational Videos for Seismic-Resistance Design Education

Utilizing videos as a tool for learning enhancement has been a longstanding practice due to their ability to captivate students' attention (Bravo et al., 2011). Low-cost instructional videos, defined as brief promotional videos with specific educational goals, are widely used to increase student engagement and motivation. These videos can be swiftly created, combined, or embedded into course materials with minimal resources, addressing common challenges such as budget constraints and time limitations. The process of incorporating videos into teaching materials is streamlined, facilitating efficient integration into educational settings.

2.1.1. *Educational videos using scale-down models*

Transforming educational videos into effective learning tools requires critically developing the associated video content from an educational perspective. Given the aim of explaining how structures respond to seismic accelerations, these videos rely on the use of scaled-down models. These models are widely employed in architectural education, with well-known advantages for teaching structural and seismic design principles (Ji & Bell, 2000; Morales-Beltran & Yıldız, 2020).

According to Ji & Bell (2000), physical models make structural concepts and principles more observable and tangible, leading to better student understanding and attention. This approach not only captures students' attention but also promotes deeper understanding. Additionally, manipulating models encourages students to construct their own meaning in acquiring knowledge, rather than memorizing information from other sources such as lecture notes (López et al., 2022). Through this technique, students engage in both surface and deep learning. Research indicates that students constructing their meaning can simultaneously lead to surface learning (e.g., memorizing model behavior) and deep learning (e.g., connecting the model's behavior to principles learned in lessons) (Biggs & Tang, 2011). Surface learning involves memorization, while deep learning focuses on understanding concepts, their reasoning, and their connections with prior knowledge. Deep learning is essential for architecture students to express their ideas and knowledge in their designs (Gunasagaran et al., 2021). Based on this information, we anticipate that through the process of model-making and reviewing the knowledge they initially acquired, students will understand, reinforce, and retain what they have learned in the long term.

The models in the videos are simplified representations of the most common residential building typology in Türkiye: multi-storey reinforced concrete (RC) frame buildings with infill walls (Gulkan et al., 2002). While the seismic behavior of such buildings is complex, simplifying the concepts into cause-and-effect relationships aids in conveying a general understanding to lay audiences. By simulating behaviors based on simple inputs (e.g., force), the models offer a visual representation of seismic phenomena without overwhelming complexity. Moreover, these models provide insights into potential building behaviors during earthquakes without directly referencing existing structures, alleviating concerns among viewers regarding the state of their own buildings. Finally, to ensure ease of replication for educational purposes, instructions for fabricating the models are provided as part of the learning experience.

Using physical models for the videos involves the process of fabricating these models by the audience, fostering active learning. While a single model (or set of related models) can be fabricated and tested during a single lesson or workshop, online how-to videos can complement this work, providing the benefits of blended learning. Also known as hybrid or mixed-mode learning, blended learning is the integration of face-to-face and online learning to enhance the classroom experience and extend learning through the innovative use of information and communications technology (Blackmore et al., 2010; Bregger, 2017; Iskander, 2007; Napakan et al., 2009). Blended strategies enhance student engagement and learning through online activities, reducing lecture time (Watson, 2008). Additional advantages include increased student retention, flexibility to study at a convenient time and place (Partridge et al., 2011), and an improved overall learning experience and outcome (Hajhashemi et al., 2016).

2.1.2. *Design and fabrication of physical models*

The video topics cover various parameters influencing the seismic performance of multi-storey RC residential buildings with infill walls, including ground motions, seismic-resistant configurations, and non-structural elements (see Table 1). The number of videos corresponds to the number of topics, plus two addressing fabrication issues. Topics were selected based on essential content recommended for earthquake-resistant building courses (Charleson, 2018). Each video features several models designed and fabricated to demonstrate key concepts, with model testing serving as a central component.

Table 1. *Topics addressed in the videos and corresponding models.*

#	Topic	Issues	Target	Models
1	Buildings' Natural Period	Ground motions & buildings Buildings' natural period (T)	Effect of seismic waves on buildings Buildings with different heights Buildings with different masses	None 1-, 8-, and 16-storey* Two 8-storey*
2	Lateral Resistant Systems	Moment frames Shear Walls Braced Frames	Effects of the connections, bracings and walls	2-storey*
3	Diaphragms and Openings	Role of the diaphragms Suitable openings placement	Flexible slab w/o penetrations	Two 2-storey forming a 3-bay structure
4	Building Configuration Irregularities - Part 1: Torsion	Torsion	Torsion due to eccentricity - Centre of Resistance Torsion due to eccentricity – Centre of Mass	8-storey*
5	Building Configuration Irregularities - Part 2: Irregular Plans & Pounding	Re-entrant corners Pounding	L-shape plans & seismic gaps Pounding & seismic gaps	1-storey* and 3-storey 3-bay
6	Building Configuration Irregularities - Part 3: Soft Storey & Short Columns	Soft stories Short columns	Soft stories / ground + infill walls Short columns / deep foundation hole & rising foundation	2-storey* 8-storey*
7	Non-structural Elements	Infill & partition walls	Role of infills - non-structural damage	2-storey*
8	Fabrication of the Shake Table	Do-it-yourself	Materials, construction & assembly process	None
9	Fabrication of the Building Models and variations	Do-it-yourself	Materials, 3D printed pieces, construction & assembly process; loading	All

* single-bay structures

The underlying assumption when using physical models to facilitate the understanding of the dynamics behind the seismic performance of buildings is that the model behaves as a full-scale building. Therefore, models are designed at a 1/60 scale, representing two actual floors per storey. While most videos feature a generic 8-storey model (Figure 1), additional models with varying storeys were utilized to highlight specific issues. Components for fabrication include 4mm wooden sticks for columns, 3mm cardboard for semi-rigid diaphragms, and customized 3D-printed pieces for connections (Figure 2). All connections are designed for easy assembly and disassembly, eliminating the need for adhesives. Comprehensive information on these models can be found in Morales-Beltran et al. (2021).

Figure 1. *Testing of generic 8-storey models (each level representing two actual building floors): before moving the shake table back and forth (left) and freeze-frame during the testing, displaying models differentiated lateral deformations (right).*

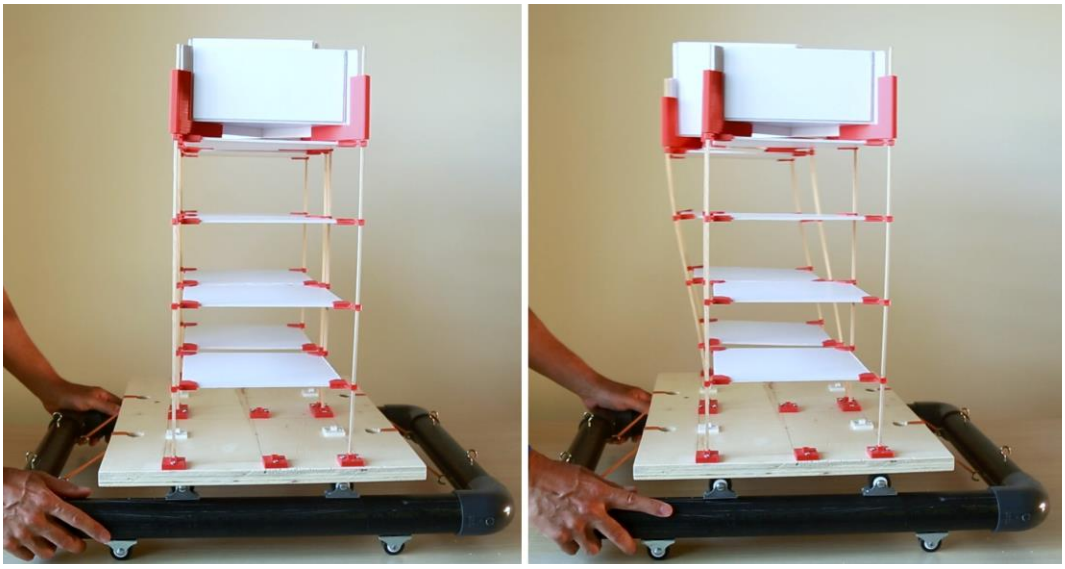
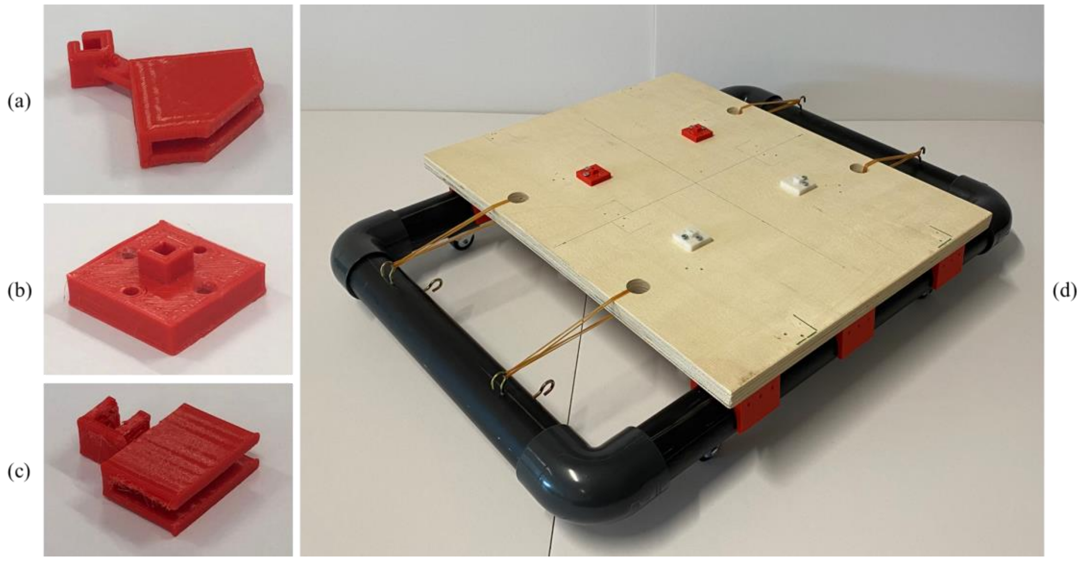


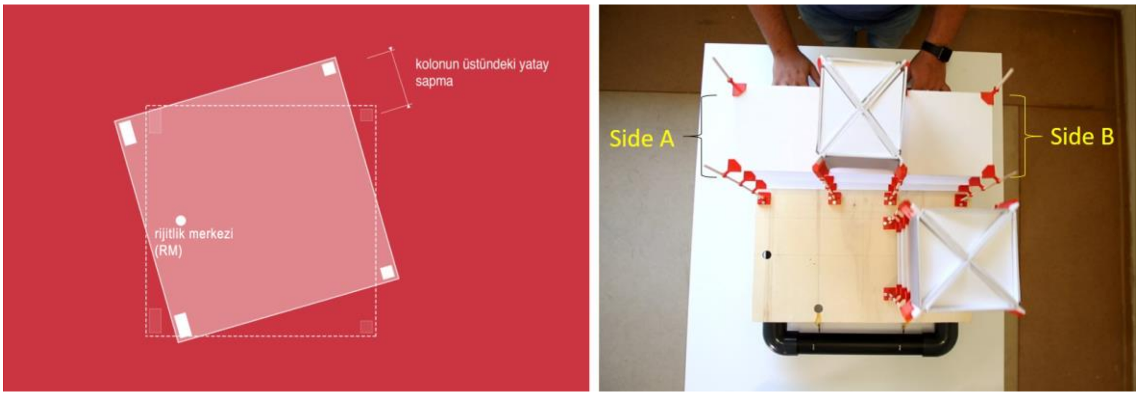
Figure 2. *image of main model components: (a) corner connections to attach a 3mm cardboard to a 4mm stick; (b) foot connections; (c) clippers, and (d) shake table components.*



2.1.3. *Video production*

Video shoots were conducted in standard classrooms, requiring minimal equipment. Each video focused on a few key aspects to facilitate student comprehension. This approach facilitates student comprehension by presenting information in manageable pieces, allowing them to control the flow of information (Brame, 2016). Once the recordings were completed, additional images and animations were incorporated to enhance the visual narration (Figure 3). Following the principles of signaling, keywords, texts, color changes, and symbols were added in various ways to highlight important information and direct viewers' attention (İbrahim et al., 2012). Additionally, videos were kept as short as possible to maintain students' interest. Research suggests that videos shorter than 6 minutes are more successful in capturing viewers' attention, while longer videos tend to lose it.

Figure 3. *Examples of visual enhancements: a GIF in high contrast used to reinforce conceptual understanding (left) and additional legends over the freeze-framed video to increase clarity of the explanation (right).*



2.1.4. *Do-it-yourself (DIY) videos*

Two supplementary videos were created to guide individuals in replicating the models and tests showcased in the educational videos. These DIY videos aim to empower instructors, architects, engineers, and builders to utilize the models for educational purposes in various settings. Digital files necessary for 3D printing components are freely accessible online, facilitating easy replication of the models.

2.2. Qualitative Analyses Using Surveys and Interviews

After observing that the videos were being watched, our goal was to understand what viewers actually learned during and after watching them. Most importantly, we aimed to determine if they acquired the expected knowledge and to what extent. To answer these questions, we conducted qualitative assessments of the video-based learning experiences, including a workshop, surveys, and interviews with architecture students. Conducting the workshop with university students offers control, monitoring, and consistency across different surveys compared to a public audience. Moreover, working with architecture students ensures they gain a deep understanding of seismic-resistant design. This knowledge is crucial because:

- Architectural decisions, especially early ones concerning building shape and configuration, significantly influence a building's seismic performance. Architects who design with an understanding of these effects can prevent irregularities and discontinuities, thereby avoiding extended damage or collapse (Charleson, 2018; Morales-Beltran & Yildiz, 2020; Özmen & Ünay, 2007).
- Architects often have direct involvement in the construction process, including acting as contractors (Dener, 1994).

2.2.1. *Workshop*

Students typically have a basic understanding of structural design by the end of their architectural education, but they may lack knowledge of seismic design principles. Therefore, the workshop was aimed at second-year architectural students at Yasar University in Izmir, Türkiye. These students were part of a course focusing on basic structural principles and had not been exposed to seismic design concepts due to the previous year's online education format caused by COVID-19. The workshop spanned three weeks and was integrated into the weekly 3-hour practice sessions of the course. Sixty-five students organized themselves into teams of 4-6 members. Teams received weekly assignments without prior knowledge of the specifics of the exercise (Table 2).

Table 2. *Main activities and assessments developed during the workshop.*

Week	Workshop	Materials	Assessment
1	Students took the baseline survey (S1) and then watched the seven* seismic-related videos in the classroom	None	Baseline S1 – Knowledge survey
2	Students took the survey (S2-1) and then began studying the assigned video and models. By the end of the session, they took another survey (S2-2)	3D connections were distributed, while students were expected to bring their own materials (cardboard, wooden sticks, etc.)	S2-1 – Knowledge survey; S2-2 – Knowledge and Validation surveys
3	Presentation and testing of the models. After that, students took the last survey (S3)	Models and beans (or similar) acting as masses	S3 – Knowledge and Validation surveys

* The other two videos describing fabrication issues were excluded.

During the second week of the workshop, teams were provided with 3D printed components to assemble their models. The number of components provided was insufficient to complete the model, testing whether students would 3D print the missing pieces or find alternative solutions. Monitoring their responses provided insights into how other students might handle similar challenges. The workshop was experimental, and participation was not graded based on performance, but merely on attendance.

2.2.2. Knowledge and validation surveys

The survey aimed to assess the seismic-related knowledge gained by students after:

- Watching seven educational videos (about 6-9 minutes each)
- Building and testing only one of the models utilized in the videos

A longitudinal panel survey was prepared to evaluate students' knowledge throughout the workshop. Eight months after the workshop, interviews with selected students were conducted based mainly on open-ended questions.

Knowledge surveys were employed to assess the learning process. These surveys present learning objectives framed as questions that evaluate mastery of specific content areas (Nuhfer & Knipp, 2003). Rather than providing direct answers, students indicate their perceived ability to answer using predefined scaled options (Wirth & Perkins, 2005). Our survey utilized a three-point scale (see Table 3), and consisted of 40 questions focusing on knowledge retention and comprehension questions structured around Bloom's cognitive domains (See Appendix 1 for full questionnaire).

Table 3. *Responses available to students for answering questions on the knowledge survey. Source: (Wirth & Perkins, 2005).*

#	Answer
1	I do not understand the question, I am not familiar with the terminology, or I am not confident that I can answer the question well enough for grading purposes at this time
2	I understand the question and a) I am confident that I could answer at least 50% of it correctly, or b) I know precisely where to find the necessary information and could provide an answer for grading in less than 20 minutes
3	I am confident that I can answer the question sufficiently well-enough for grading at this time

Despite the widespread acceptance of knowledge surveys as effective learning assessment tools, there is a recognized concern about their reliability as indicators of student understanding

(Wirth & Perkins, 2005). In their study, Wirth and Perkins compared knowledge surveys with students' exam scores and final grades to assess the reliability of the primary survey. To ensure the validity and consistency of our survey results and mitigate potential biases—such as students feeling compelled to demonstrate confidence—we included validation surveys in the second part of the workshop (see Table 2).

In these validation surveys, students were instructed to choose one question per section (each section corresponding to a specific video and containing up to 6 questions) and answer it as they would in a regular test. Therefore, each validation survey contained only seven questions. Subsequently, instructors evaluated and categorized these responses using the same three-point scale as the knowledge survey (Table 3), establishing *key answers*. The numerical difference between the key answers and students' responses (Δ) indicates the level of agreement or discrepancy between the surveys. Additionally, the Δ value serves as a measure of the reliability and credibility of students' answers.

2.2.3. *Interviews with students*

The purpose of conducting interviews was to gather comprehensive data on the effectiveness of visual media and models as learning tools for understanding seismic design principles. Semi-structured, in-depth interviews were chosen as the method of data collection due to their flexibility in adapting to a predefined set of open-ended questions and allowing for spontaneous follow-up questions during interactions between interviewers and interviewees (DiCicco-Bloom & Crabtree, 2006). In-person interviews were preferred because they enable interviewers to capture participants' verbal and non-verbal cues, which often provide insights that can lead to further exploration (Adeoye-Olatunde & Olenik, 2021).

The overarching aim of using individual semi-structured interviews was to provide a clear and focused structure for discussions while also allowing space for participants to express their individual perspectives. This approach facilitated gathering diverse data on similar topics from different participants (Kallio et al., 2016). The interviews were based on semi-open questions organized into four main sections (full description in Appendix 3: Interview Questions):

- Video: Recollection of what participants remembered from the videos and what aspects helped them understand.
- Working: Assessment of how influential the videos were in the process of constructing the models.
- Testing: Comparison of participants' testing processes with those demonstrated in the videos.
- Learning: Reflection on what participants perceived they had learned and areas where their understanding might still be lacking.

Additionally, the interview included three supplementary parts: soliciting suggestions for improvement to encourage forward thinking, exploring participants' learning processes to foster reflection, and a brief survey. In this survey, participants were asked to consider themselves as active learners tasked with teaching other students the content covered in the knowledge surveys. They indicated whether they would use a model or a video for each question to facilitate teaching.

The in-person interviews were conducted between January and February 2023, more than eight months after the surveys were administered. Fourteen students, two from each video group, were selected based on their high scores in the surveys, specifically those showing the best alignment between their validation survey responses and the key answers. Eleven students (St01-St11) accepted the invitation. They were informed in advance that the interview would focus on their previous coursework in statics, without specific reference to the workshop involving videos and models. This approach aimed to prevent students from preparing by revisiting the videos. Interviews were conducted in both English and Turkish based on students' language preference and comfort level in expressing their thoughts.

3. RESULTS

3.1. Performance of The Videos in The Youtube Channel

All nine videos were uploaded to a YouTube channel named "Earthquakes & Buildings" (BAP103-Deprem & Binalar, 2021) between June 2021 and February 2022. A year later, the channel had gained 221 subscribers and accumulated approximately 3,600 views of the videos. By May 2023, the channel's subscriber count had increased to 858, with the videos collectively receiving about 16,300 views. Excluding the do-it-yourself videos, a significant percentage—ranging between 74% and 90%—of these 16,000+ views occurred only after the Kahramanmaraş Earthquakes of February 6, 2023 (Table 4). This increase in viewership can be interpreted as people seeking answers, particularly amid uncertainties regarding building collapses and construction quality in the aftermath of the earthquakes. The fact that the most-watched videos maintained an average viewing time of over 50% indicates that the videos successfully held the viewers' attention.

Table 4. *List of videos of the "Earthquakes & Buildings" YouTube channel by May 2023, organized by number of total views.*

#	Video	Duration	Average Watching Time	Uploaded	Views	
					Total*	After 06/02/2023
6	Building Configuration Irregularities - Part 3: Short Columns & Soft Storey	07:19	51%	01/2022	4780	90%
1	Natural Period of Buildings	05:27	54%	06/2021	3644	83%
4	Building Configuration Irregularities - Part 1: Torsion	07:48	51%	10/2021	1866	74%
7	Non-structural Elements: Infill Walls	05:17	51%	02/2022	1339	77%
2	Lateral Force-Resistant Systems	09:14	47%	10/2021	1269	79%
5	Building Configuration Irregularities - Part 2: Irregular Plans & Pounding	09:20	49%	12/2021	1189	74%
3	Diaphragms and Openings	08:27	47%	02/2022	905	77%
8	Fabrication of the Shake Table	07:00	22%	06/2021	867	36%
9	Fabrication of the Models	07:09	23%	01/2022	402	22%

*As of 24/05/2023

3.2. Survey Results

Sixty-five students initially participated in the workshop, but active involvement and consistent survey responses were maintained by 51 students. Hence, the results are based on these 51 surveys, focusing on knowledge increase and survey consistency.

Since the baseline (S1) and S2-1 are knowledge surveys, the results consider the answers given by all 51 students to all questions. After the teams were assigned specific videos, they separately focused on each video-related work. Since S2-2 and S3 are both knowledge and validation surveys, i.e. students choose a question to be answered, their results separately account for the answers given only by the teams working on each of the seven videos. Consequently, the scores per video in S1 and S2-1 were computed using 51 answers, whereas the scores per video in S2-2 and S3 were computed using only between eight and ten answers.

3.2.1. *Knowledge increase*

3.2.1.1. Most frequently selected questions for answering. The validation survey required students to select and answer one question from each of the seven topics covered in the knowledge survey. Table 5 highlights the questions most frequently chosen for answering in each section.

In the baseline survey (S1), questions such as “What is an earthquake?”, “What is center of mass”, and “What is the most common type of non-structural infill wall used in Türkiye” (questions 1, 19, and 36 respectively) received relatively higher scores, suggesting existing prior or common knowledge among the students. The consistent average scores across subsequent surveys support this observation. For the other four videos, there was a notable increase in scores in S2-1 (taken after watching all videos). It indicates that the videos contributed significantly to the students' understanding.

The average scores in S2-2 and S3 reflect answers only from students who constructed the model(s) related to the assigned video. Each video was assigned to two teams with four or five members each, resulting in between eight and ten students per video topic by the final survey.

While the score variations in Table 5 do not follow a distinct pattern, the significant variation observed in question 17's scores is noteworthy. The increase in S2-1 compared to the baseline survey indicates that the videos helped most students understand the optimal location for openings in a diaphragm. However, the lower score in S2-2 suggests that fewer students assigned to study that specific video had a strong grasp of the topic. The subsequent increase in S3 compared to S2-2 demonstrates that constructing models enhanced understanding among the students working on that video.

Table 5. *Average score of the most frequently selected to-be-answered question in validation surveys.*

Video		Knowledge Survey		Average score			
#	Topic	No.	Question	Baseline*	S2-1*	S2-2**	S3**
1	Natural Period of Buildings	1	What is an earthquake?	2.75	2.71	2.60	2.60
2	Lateral Force-Resistant Systems	7	Why vertical continuity is fundamental to provide buildings with adequate resistance to earthquakes?	1.75	2.08	2.30	2.30
3	Diaphragms and Openings	17	From a seismic-resistance perspective, where is the best location to make openings in the diaphragm?	1.18	2.24	1.33	2.50
4	Torsional Behaviour	19	What is Centre of Mass?	2.49	2.65	3.00	2.88
5	Irregular Plans & Pounding	26	Why irregular plan layouts can be potentially dangerous during earthquakes?	1.90	2.41	2.30	2.60
6	Short Columns & Soft Storey	29	What is a short column?	1.86	2.45	2.57	2.71
7	Non-structural Infill Walls	36	What is the most common type of non-structural infill wall used in Türkiye?	2.06	2.26	2.50	2.17

Score ranges between 1 and 3
* All students’ answers in the knowledge surveys
** Considering only the answers from students who worked with the specific video topic

3.2.1.2. Least frequently selected questions for answering. Examining the least frequently chosen questions provides insights into the subjects that challenged students' understanding the most. The variations across surveys offer clear indications of the students' learning progression. As depicted in Table 6, positive variations between S2-1 and the baseline survey for all videos suggest that students made learning gains after watching the videos. Similarly, between S3 and S2-2, positive variations are observed in 6 out of the 7 videos, indicating enhanced learning after constructing and testing models.

Notably, the substantial increase in S3 compared to S2-2 for question 23 suggests that constructing models related to video #4 significantly improved students' understanding of buildings' torsional behavior. The exception is question 34, concerning soft storey mechanisms, where the negative variation between S3 and S2-2 may indicate that constructing models did not effectively enhance students' comprehension of this topic.

Table 6. *Average score of the least frequently selected to-be-answered question in validation surveys.*

Video		Knowledge Survey		Average score			
#	Topic	No.	Question	Baseline*	S2-1*	S2-2**	S3**
1	Natural Period of Buildings	3	What are ground motions?	2.12	2.37	2.40	2.40
2	Lateral Force-Resistant Systems	12	What are the most common configurations of braced frames?	1.20	1.98	2.00	2.40
3	Diaphragms and Openings	14	What is the role of a diaphragm in providing seismic resistance to buildings?	1.22	1.96	1.67	2.00
4	Torsional Behaviour	23	How does eccentricity affect the torsional behaviour of a building during an earthquake?	1.18	1.90	1.63	2.75
5	Irregular Plans & Pounding	28	In practice, how wide should the seismic gap be?	1.37	2.10	2.40	2.60
6	Short Columns & Soft Storey	34	Why soft storey mechanisms are dangerous?	1.37	2.10	2.43	2.29
7	Non-structural Infill Walls	38	What type of damage appears when infill walls resist in-plane inertia forces?	1.25	1.94	1.83	2.33

* Considering all answers.
** Considering only answers from students who worked with the specific video topic.

3.2.1.3. Average score variation (Δ) between surveys. The average score variation (Δ) between surveys provides a measure of the changes in students' understanding over time. Positive variations typically indicate learning gains. Survey S2-1, conducted after students watched the videos, shows the largest positive variations compared to the baseline survey (Table 7), indicating learning through video instruction. The greatest improvements between S2-1 and S1 relate to questions associated with video #3, followed by those of video #4 and #2.

Table 7. *The seven highest increase in the average difference of scores (Δ) between S2-1 and Baseline.*

Video		Knowledge Survey		Δ S2-1 – Baseline
#	Topic	No.	Question	
3	Diaphragms and Openings	17	From a seismic-resistance perspective, where is the best location to make openings in the diaphragm?	1.06
		16	From a seismic-resistance perspective, where is the worst location to make openings in the diaphragm?	1.02
4	Torsional Behaviour	21	What is Centre of Resistance?	0.96
2	Lateral Force-Resistant Systems	8	Why seismic resistance must be provided in both orthogonal plan directions?	0.90
4	Torsional Behaviour	20	What is Stiffness?	0.88
6	Short Columns & Soft Storey	31	Which design solutions help to prevent short columns mechanisms in buildings during earthquakes?	0.86
3	Diaphragms and Openings	13	Which structural elements in buildings are considered as diaphragms?	0.84

Survey S3, conducted after students constructed, tested, and presented their models, reflects learning from hands-on modeling, testing, and discussions with instructors. The largest improvements between S3 and S2-2 (Table 8) are observed for videos #3 and #4, suggesting that students' understanding of these topics significantly improved after engaging with physical models.

These findings highlight the effectiveness of both video-based instruction and hands-on modeling in enhancing students' comprehension of seismic design principles. The positive score variations across surveys underscore the benefits of combining theoretical instruction with practical application in educational settings.

Table 8. *The seven highest increase in the average difference of scores (Δ) between S3 and S2-2.*

Video		Knowledge Survey		Δ S3 – S2-2
#	Topic	No.	Question	
4	Torsional Behaviour	22	What is Eccentricity?	1.25
3	Diaphragms and Openings	17	From a seismic-resistance perspective, where is the best location to make openings in the diaphragm?	1.17
4	Torsional Behaviour	23	How does eccentricity affect the torsional behaviour of a building during an earthquake?	1.13
		20	What is Stiffness?	0.63
		21	What is Centre of Resistance?	0.63
7	Non-structural Infill Walls	38	What type of damage appears when infill walls resist in-plane inertia forces?	0.50
3	Diaphragms and Openings	15	Why openings might jeopardize the structural integrity of a diaphragm?	0.50

3.2.1.4. Average score variation (Δ) between key answers. To calculate the factored average score (Sf) for each question j in surveys S2-2 and S3, we use Equation 1:

$$Sf_j = (\sum_{i=1} s_{i,j})/n \quad \textit{(equation 1)}$$

Where:

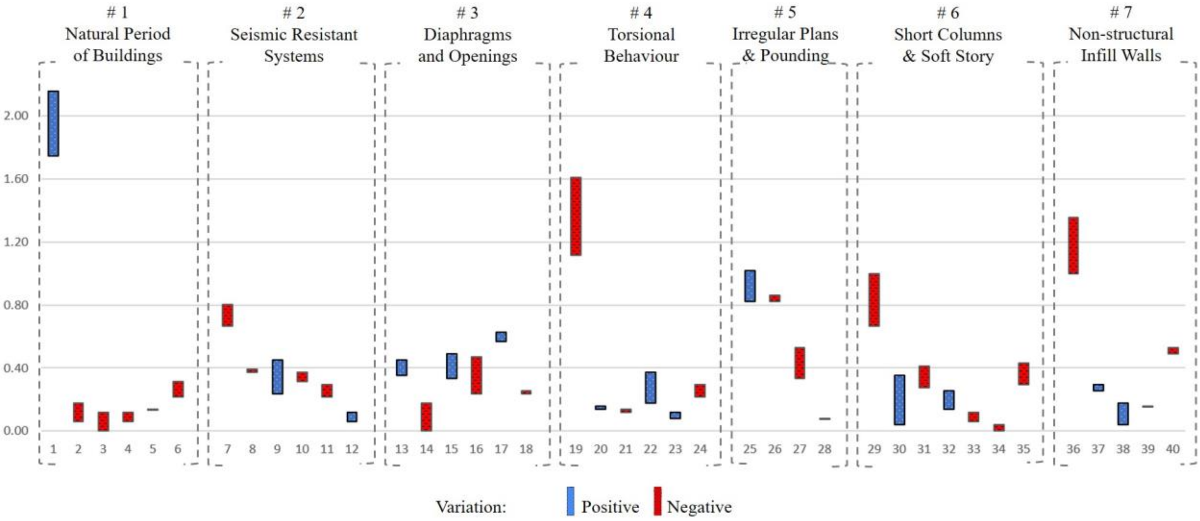
- *Sf* is the factored average score for question j,
- *s* is the score of each answer i given to question j,
- n is the total number of answers given (in this case, 51).

This computation allows us to assess positive or negative variations between the scores of S3 and S2-2. Positive variations indicate increased learning, while negative variations suggest the opposite.

In Figure 4, which displays these factored scores per survey, questions such as "what is an earthquake" (1), "what is the centre of mass" (19), and "what is the most common type of non-structural infill wall used in Türkiye" (36) received the highest number of responses. However, questions 19 and 36 show negative variations, indicating that the average scores in S3 were lower than in S2-2 for these questions.

This analysis helps in understanding how students' understanding evolved between the validation surveys S2-2 and S3, particularly for questions that received significant responses and exhibited notable score variations.

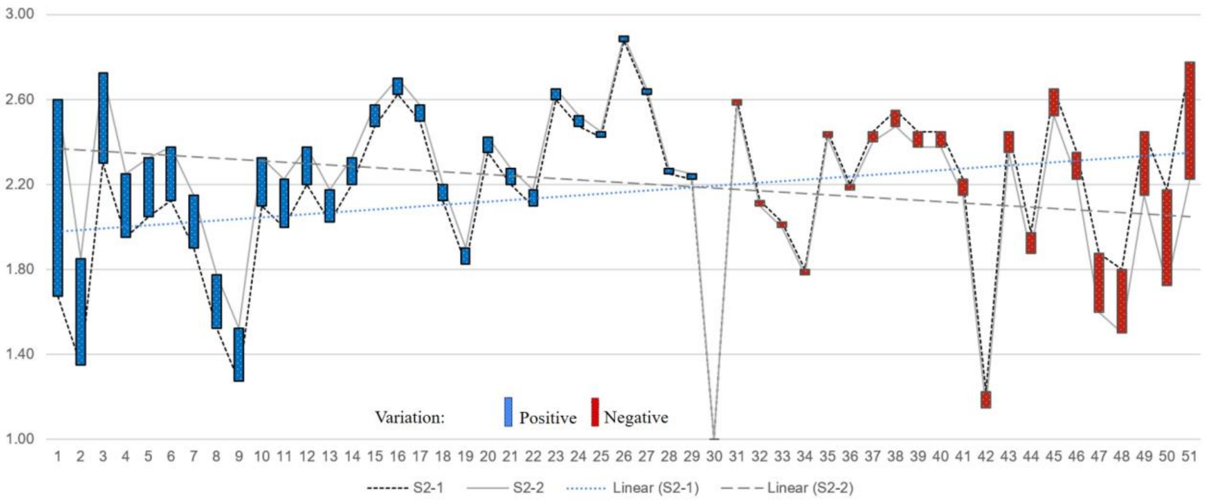
Figure 4. *Variations of the average test responses (key answers) between S2-2 and S3 surveys. Higher vertical placement indicates higher number of answers, while length of bars indicates the degree of variation.*



3.3.1. *Surveys' consistency assessment*

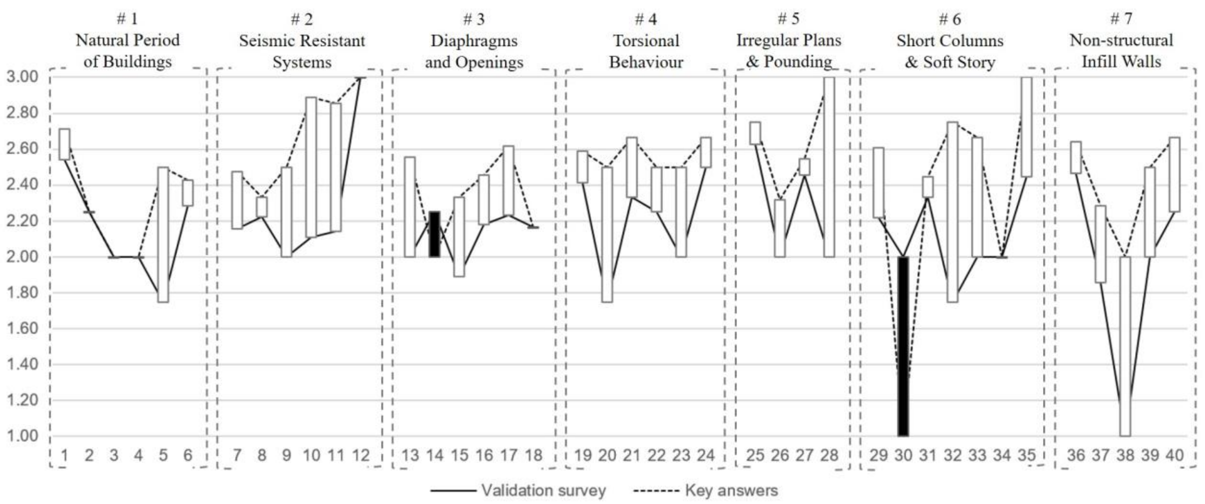
3.3.1.1. Score variations between S2-2 and S2-1. S2-2 was administered shortly after S2-1, with the key difference being that students were aware their perceived knowledge levels would be tested during S2-2. Therefore, variations between their responses in these surveys serve as indicators of students' credibility and, consequently, the reliability of the assessment. In Figure 5, average scores per student from both surveys are arranged in descending order, with the highest positive and negative scores at the right and left ends, respectively. The slight increase in S2-2, with an average score of 2.21 compared to 2.16 in S2-1, reflects the expected outcome that students would perform slightly better after engaging with the videos. The overall average variation of 0.04 shows that 29 answers scored higher in S2-2 ($\bar{x} = 0.18$), while 21 scored lower ($\bar{x} = -0.14$).

Figure 5. *Average score per student in S2-1 and S2-2 organizing in decreasing order.*



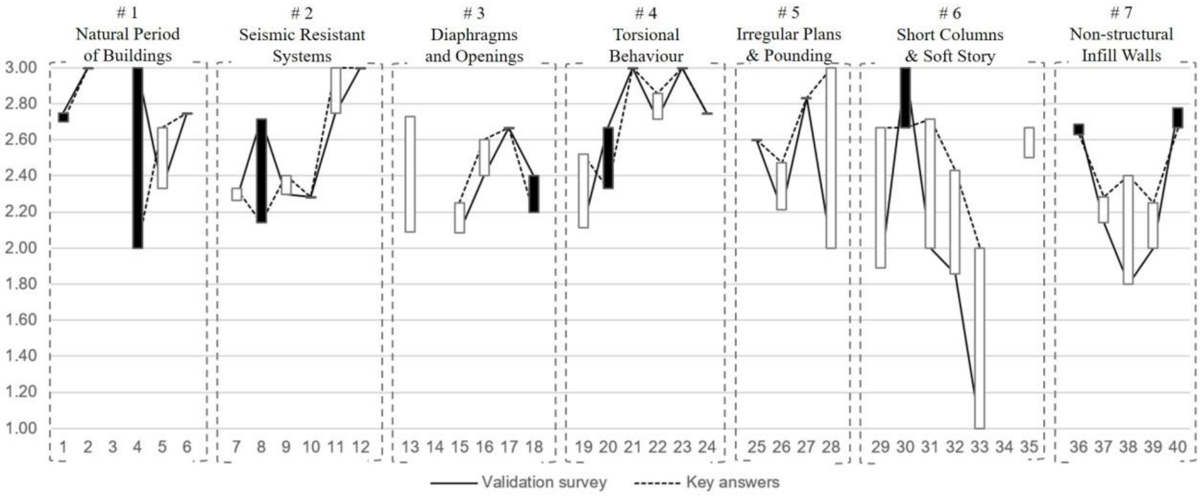
3.3.1.2. Score variations between validation surveys and key answers. Analyzing the average scores of both key answers and students' responses by each video reveals significant discrepancies between students' perceived knowledge (validation survey) and their actual understanding (key answers). Trends observed in S2-2 (Figure 6) indicate that in most questions, students underestimated their knowledge. A notable example is question 38 ("What type of damage appears when infill walls resist in-plane inertia forces?"), where students' average score was 2.0, while they rated their own understanding at 1.0—the lowest possible score. Conversely, in question 30 ("In which situations do short column mechanisms tend to appear in buildings?"), students displayed overconfidence in their knowledge. There were four matches (equal key and students' scores) in S2-2, which doubled in S3.

Figure 6. *Average score variations between the validation survey and key answers after S2-2.*



Moreover, students' overconfidence is apparent in the trends observed in S3 (Figure 7). For instance, in question 30, both the average scores from validation surveys and key answers increased compared to S2-2, indicating students still perceived themselves to know more than they actually did. However, question 4 ("How do ground motions affect buildings?") showed a slight decrease in scores, and question 33 ("What is a soft storey?") saw a decrease from 2.0 to 1.0 in validation surveys (students' perceived knowledge) and from 2.67 to 2.0 in key answers (actual knowledge).

Figure 7. *Average score variations between the validation survey and key answers after S3.*



3.4. Interview Results

The main insights gathered from the interviews are presented below, categorized based on the students' responses to four main aspects: video, working, testing, and learning.

3.4.1. *Techniques to improve retention from videos*

When discussing aspects they liked about the videos, students primarily highlighted:

- Short duration: Students appreciated the brevity of the videos, noting that lengthy videos hindered their concentration. They found shorter, clear explanations facilitated better understanding.
- Single focus: All students agreed that focusing on one topic per video enhanced clarity.

Regarding attention-grabbing features, students positively evaluated:

- Use of keywords: Highlighting keywords in contrasting colors aided in understanding and retention, e.g., "the background was red, and the text was white. It is useful to understand and remember short words. They were helpful." (St09).
- Visual differentiation: Different colors and materials used for different components of the model helped distinguish parts effectively, e.g., "the connections were orange or red, floors were white, and columns were timber. We could differentiate the parts of the model." (St08).
- Visual explanations: Students found visual aids such as drawings, images with explanations, and annotations fundamental in enhancing comprehension, e.g., "sometimes the video stopped, images appeared on the screen, and had explanations on it. I think this was very helpful to keep the focus and to understand." (St07).
- Additional use of visuals, such as lines, arrows, and letters: "Like deformation arrows and displacements: showing torsional effects with arrows, bending deformations of the floors made graphic explanations clear, so I understood better." (St03).

3.4.2. *Retention & learning*

All students remembered the main subject of their assigned video. For instance, a student explained, "We were supposed to show the torsion behaviour." (St01). Some of them could even describe the models involved: "The video was about shear walls. We compared 4-, 8-, and 16-storey building models with and without shear walls." (St07). However, most students provided vague explanations of the video's purpose: "With our models, we compared different possibilities under earthquake effects." (St07), or "We tested the earthquake resistance of the model in terms of damage." (St09).

Students appreciated the accessibility of the videos, allowing them to watch repeatedly at any time: "We had access to the videos all the time because they were in YouTube." (St08). This accessibility led to several benefits:

- Learning technical terms: "I think I have learned the meanings of the terms. I cannot remember now, but at that time, I understood. We watched all the videos three or four times." (St01).
- Understanding details: "After watching it repeatedly, I discovered details. When I first watched it, I understood the given topic generally. But then when I watched it again, I realized the details." (St09).
- Increased retention: "At the time we watched the videos in the classroom, we watched them several times. And each time, we answered some questions. After we watched it again and again, I was able to answer those questions easier." (St04).
- Actual learning: "We have worked on short columns, but we watched and learned all the videos. Of course, we learned things about buildings, stability, and earthquake-resistant buildings. We learned like statics of the buildings or how we can create openings on the slab, like we shouldn't make an opening in the corner of the slab, etc." (St08).

3.4.3. *Video as source of information for making models*

Students found videos instrumental in model construction due to their ability to revisit and review. Additionally, videos contained diagrams and a digital axonometric drawing that "really explained the logic of the model." (St03). Since there were specific and clear explanations, "making the model was easy." (St07). Without videos, the assembly part would have been the hardest: "Especially for the connections—we would have gotten confused without the videos." (St11).

Videos demonstrated model behavior on shake tables, helping students to prepare both the model and testing procedure: "it was easy to make the test when you know how the model is supposed to act under forces in that test" (St07). In addition, videos helped students verify the accuracy of their models: "In the preparation stage, we compared our models with another group. We saw that they were doing some parts differently, so we checked the video again. Then we understood that we had missed those parts so we prepared them again quickly." (St05).

3.4.4. *Main benefits of the whole workshop*

All interviewed students expressed a positive evaluation of the workshop , highlighting key learning outcomes:

- Understanding theoretical contents, which sometimes remain unclear to the students: "Sometimes in the statics course, the information seems mostly theoretical for us, but with physical models, it was much clear than a normal lecture." (St01).
- Enhanced technical terminology: "While answering the survey questions, I realised that my technical vocabulary has improved with this study." (St07).
- Integration of technical knowledge: Students noted improved comprehension of structural aspects relevant to architectural design. "For example, in the studio, sometimes instructors commented that L-shaped buildings do not work correctly from a structural point of view. Now I can understand this, and sometimes I can also see that a design will not work too." (St07).

3.4.5. *Suggestions for improving learning with videos*

When asked for suggestions to enhance future workshops, students proposed:

- Using case studies: Incorporating real building examples to deepen understanding of complex phenomena like soft storeys or short columns.
- Adding closing summaries: Requesting concise summaries at the end of videos containing technical information.
- Question and answer sessions: Suggesting interactive sessions after video viewings to clarify concepts. This suggestion must be understood in the context of students watching the videos during the class.

3.4.6. *Sources to learn from*

Students ranked activities of the workshop based on their perceived contribution to understanding video topics:

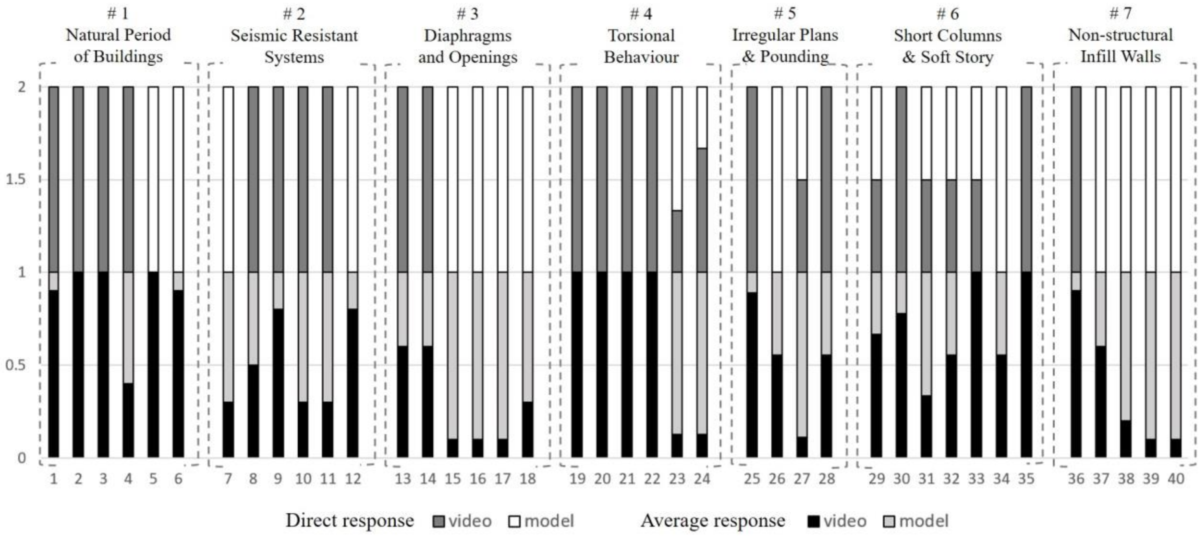
- Watching videos contributed the most, followed by testing models. Five students chose this order, arguing that while testing helped them to get "the main idea" of the model, videos provided more general knowledge.
- Testing models contributed the most, followed by watching videos. The main argument for the second most frequently chosen order was that only through testing was it possible to understand the functional purpose of the model.

Interestingly, *making* models was not widely seen as a significant tool for learning seismic design concepts, possibly due to its perceived commonality in architectural education.

3.4.7. *Active role survey*

Students were asked how they would use models or videos to teach others about workshop topics. Since each of the interviewed students worked with a particular video, their answers for that particular video's questions constitute the so-called direct response, separated from the average response—obtained from students who did not work with that video (Figure 8).

Figure 8. *Direct (top) and average (bottom) responses to whether students would use videos or models to teach the content of each question.*



Results show that:

- Direct and average responses indicated agreement that videos were suitable for explaining most topics except for videos #3 and #7, where models were preferred.

- Direct responses of videos #1 and #2 indicate that at least two questions could be explained using only models, which contradicts the general tendency.

Discrepancies were noted, such as in question 5, where direct responses favored models while average responses did not. Questions 10 and 11 received full agreement for using videos in direct responses but only 30% in average responses. Conversely, questions 6 and 12 received full agreement for using models in direct responses but little in average responses.

4. DISCUSSION

The primary objective of the videos as educational tools is to disseminate accurate seismic-related knowledge effectively to both the general public and professionals lacking engineering backgrounds (Musacchio et al., 2016). The authors believe that visual content supported by practical models aids non-specialized audiences in understanding fundamental principles governing building behavior during earthquakes (Wang, 2022). By promoting knowledge about seismic design, these videos and models serve as potent tools for raising community awareness about disaster risk reduction (Benadusi, 2014), particularly on those risks associated with constructing or modifying buildings without considering their seismic behavior.

4.1. Importance of Videos' Free Access and Full Availability in Rising Seismic Awareness

Increasing public awareness is crucial for mitigating loss of life and economic damage during earthquakes (Nathe, 2000). Achieving this through educational videos requires two key components. Firstly, videos should be freely accessible, leveraging platforms like YouTube to maximize accessibility across diverse demographics. Secondly, timely availability is critical; viewership statistics (see Table 4) illustrate that views surge following significant earthquakes. This underscores the importance of having educational resources readily available during such critical periods.

4.2. Videos as a Learning Tool

In line with related research highlighting the use of key components to balance cognitive load (de Koning et al., 2009), video-based learning strategies in this study were enhanced by signalling (Ibrahim et al, 2012). As expected, signalling did facilitate students' retention of the subjects (Nevid & Lampmann, 2003), through three strategies:

(i) introducing a simplified version of the theorical framework by adding texts, images, and tailored animations (Moreno, 2007);

(ii) highlighting specific aspects during the explanations by freezing an image or "zooming-in" to focus on specific details (Castro-Alonso et al, 2019); and

(iii) complementing the actual testing with annotations and legends to facilitate the assimilations of key concepts, measures, or data (Kruger & Doherty, 2016).

Since the videos are always available online, students valued the flexibility to watch content at their convenience and repeatedly if necessary, reinforcing positive attitudes towards this learning method (Kelly et al., 2009). Although videos were kept relatively short—following suggestions in related literature (Ahn & Bir, 2018)—averaging around 7 minutes and 33 seconds, statistical evidence (see Table 4) suggests that even shorter durations could enhance effectiveness, given that average viewing times were approximately 50% of video lengths, suggesting optimal lengths closer to 3 minutes and 45 seconds.

The 50% average watching time refers to views of the videos by random people, including the students who were tasked with fabricating the models presented in them. One may suppose that, contrary to regular viewers, students would tend to watch the whole video. To test this hypothesis, we compared the probable time at which people usually stopped watching the video against the times when the most and least frequently chosen questions were actually answered in the videos (Table 9). Except for video #3, the most frequently chosen questions were answered within the average watching time. Regarding the least frequently chosen questions, except for videos #1 and #3, all questions were answered beyond the average watching time.

These matching trends seem to indicate that students also watched the videos for an average time equal to half of the actual video length, even when they were supposed to watch it in full. Whether this occurred due to students losing interest in the video or having short attention spans, this observation seems to confirm the idea that shorter videos (approximately 3 minutes and 45 seconds) would be more effective as a learning tool.

Table 9. *Comparison of the probable time at which people usually stopped watching the video against the times where the answers to the most and least frequently chosen questions were given.*

#	Video	Inferred average time at which people stopped watching the video*	time at which the answer was given in the video	
			for the most-frequently chosen questions**	for the least-frequently chosen questions***
1	Natural Period of Buildings	02:56:35	00:30:00	00:49:00
2	Lateral Force-Resistant Systems	04:20:23	02:31:00	06:00:00
3	Diaphragms and Openings	03:58:17	06:56:00	03:04:00
4	Building Configuration Irregularities - Part 1: Torsion	03:58:41	00:25:00	04:15:00
5	Building Configuration Irregularities - Part 2: Irregular Plans & Pounding	04:34:24	01:32:00	07:19:00
6	Building Configuration Irregularities - Part 3: Short Columns & Soft Storey	03:43:53	01:05:00	04:36:00
7	Non-structural Elements: Infill Walls	02:41:40	02:00:00	02:50:00

* based on Table 4.

,* in reference to questions displayed in Table 5 and Table 6, respectively.

4.3. Monothematic Videos Versus Short Columns & Soft Storey Mechanisms

All videos, except for video # 6—Building Configuration Irregularities - Part 3: Short Columns & Soft Storey, are monothematic. Unlike video # 5, which also includes two concepts (pounding and irregular layouts), the two topics presented in video #6 are not necessarily related nor were explained as such. Hence, in practice, there are two distinct topics within this single video.

The decision of merging them was based on that, otherwise, separate videos would be too short. However, judging by the contradictory results of the surveys, this might not have been the best idea to enhance common knowledge on these subjects. Simultaneously, but not surprisingly, video #6 is the most watched video on YouTube (Table 4).

Upon close examination of the surveys' results, questions related to video #6 display a fairly erratic pattern. Question 34—Why soft storey mechanisms are dangerous?—is one of the least frequently chosen question to answer across all surveys (see Table 6). Conversely, question 29—What is a short column?—is one of the most frequently chosen (see Table 5). This confidence seems to be reflected in the average responses to question 31—Which design solutions help to prevent short columns mechanisms in buildings during earthquakes?—which showed a significant increase between S2-1 and baseline surveys (see Table 7). Although this increase may indicate gains in knowledge after watching the videos, no question from video #6 was among the highest increases between S3 and S2-2 (see Table 8). Moreover, question 30—In which situations short column mechanisms tend to appear in buildings?—displayed the largest negative difference between validation and key answers in S2-2 (Figure 6) and remained negative even after S3 (Figure 7).

Due to these inconsistencies in the students' responses, whenever mentioned during the interview by a student, we asked them to explain the concepts of soft storey and/or short column mechanisms in their own words. From these explanations, it seems that while the concept of a soft storey is generally fairly understood, the notion of a short column—as suspected, is highly misleading. For example, one student correctly elaborated on the soft storey: "There was an example from [a building in] Türkiye with commercial areas in the ground floors, so without walls. But the upper floors had walls because those were residential. This created the soft storey problem. Also, in another example, […] there is an apartment [building] with 3 stories, and the middle one is higher than the others, so this also creates the [soft-storey] problem." (St03).

The confusing aspect of the short column irregularity is that, while it seems like a quite obvious issue, its negative implications for the seismic behaviour of buildings are far less clear: "A short column is a column shorter than the other ones and it affects [the] *statics* [sic] of the building because it doesn't have balance." (St08). Another student openly expressed that she did not understand this concept and when asked why, she answered: "Because I didn't see it or hear it before. For example, where can we use that kind of columns?" (St01).

Another, or perhaps additional, explanation could be rooted in an oversimplification of the phenomena behind the soft storey and short columns mechanisms. Since the use of educational videos is somewhat limited to basic and simplified language, this simplification might undermine the efforts to introduce rather elaborated analyses or notions. In the pursuit of a wider overview rather than an in-depth understanding, such simplified explanations often avoid the inherent complexity of the dynamics involved in the seismic response of real structures, such as multi-storey buildings. For this reason, to prevent misunderstanding due to oversimplification, basic videos could be complemented with media targeting advance knowledge and a highest level of detailing.

4.4. Learning by Making The Models or Testing The Models?

If we accept that positive variations in the average scores of successive surveys indicate students' increased learning, then the major knowledge gains took place after students watched the videos. Similarly, the comparatively small increases in S3 with respect to S2-2 could be understood as if working with models effectively enhanced students' understanding. However, this effect may be influenced, at least partially, by students learning by re-watching the videos for the purpose of making the models.

Despite the predominance of video-based learning, the survey results provide some evidence that students learned from the working with models, especially in video # 4. Question 22 about eccentricity appears as one of the least frequently selected, but then it also appears in the largest increase towards S3. This is a clear indication that students who particularly worked with those models did increase their understanding of the video subjects by making and testing the models. Similarly, the larger increase in S3 with respect to S2-2 of question 23 seems to prove that by making models of video #4, students did improve their understanding of buildings' torsional behaviour.

The idea that videos might have been more effective as a learning tool than models is reinforced by the interview results. When forced to choose between videos or models to hypothetically teach the survey contents, the overall opinion is that most of the survey contents could be explained using only videos. Moreover, during the interviews, the unanimous opinion was that videos were useful for making the models.

Another overall opinion is that some topics of videos #3 and #7 could be explained by models. The students who worked with videos #1 and #2 believed that at least two questions in there could be explained by models. Interestingly, the main issue here is that "teaching with models" does not explicitly refer to either making or testing them, so it is unclear what this choice means in the minds of the students.

During the interviews, students expressed that they learned by *testing* the models, yet they seem to see little-to-no knowledge gain in *making* the models. This may appear contradictory, yet one way to interpret it is that students value the fact that models (as used in the videos) do help them to grasp the targeted learning outcomes, but they tend to dismiss the making of the model as a learning tool for seismic design inputs.

The interviews showed that the most probably reason for model making not significantly helping students to increase their knowledge is that they focused more on the fabrication aspects of the models, rather than on understanding the phenomena these were intended to demonstrate.

Models, unexpectedly, posed a great challenge for the students in terms of fabrication. During the interviews, most of their observations focused on how easy or difficult it was to make the assigned model and how much information they could obtained from the videos. They even tended to judge the videos based on this latter perspective. One plausible explanation for this struggle is the fact that these students had their first year of architecture under an online education system—thanks to COVID-19—so by the time they were asked to make the models, they had only one semester of experience in model making.

Despite the models being supposed to reinforce the lessons learned in the videos, they became an independent problem to be solved in a short time (one week). Therefore, the effects of the simulated earthquake shaking were important for the students only in terms of whether the model worked as in the video or simply collapsed.

4.5. Surveys' Reliability

The relatively small variations between the average scores of validation survey and key answers are a clear sign of the reliability of the assessment. However, despite a good level of agreement between answers (students and key), the positive difference in S2-2 seems to indicate hesitation of the students, while the appearance of negative variations in S3 may indicate overconfidence of students in certain aspects. This overconfidence might be natural or perhaps is the result of students being exposed constantly to the same subject for three weeks. This cannot be attributable to low-skilled students typically overestimating their performance-the Dunning-Kruger effect (Feld et al., 2017)-simply because if so, overconfidence would have been evident also in S2-2. Among several factors that could possibly produce overconfidence, including gender, cultural background, educational levels, and even performing hard tasks, one feasible factor in this case may be overconfidence due to having more information (Oskamp, 1965—as cited in (Wüst & Beck, 2018)).

5. CONCLUSION

The presented study aimed to increase seismic-related knowledge of non-specialized audiences using videos and physical models. The freely available videos on YouTube, coupled with enhanced signalling, are the key features that make these educational media effective in raising seismic awareness in communities susceptible to be affected by future earthquakes.

A subsequent workshop with architecture students was conducted to assess the effectiveness of this method as a learning tool. Post-workshop surveys and interviews with students revealed the following key findings:

- Videos produced in the presented way are effective tools for enhancing learning in students without prior knowledge of seismic design of buildings.
- Educational media dealing with complex subjects, such as seismic design, should be monothematic. This study suggests that merging two subjects within one video prevent students from a clear understanding of key concepts.
- Evidence from surveys and interviews indicates that students attribute knowledge gains to models when used to explain specific topics, such torsional behaviour, the role of diaphragms, and performance of non-structural components.
- Despite the positive evaluation of *testing* models, students, in general, perceive little-to-no knowledge gain in *making* the models. The reasons for this perception are uncertain; however, one plausible argument is that the participant cohort had little experience working with physical models.

These observations may serve as guidelines for incorporating these tools into teaching strategies for seismic-related courses in Architecture.

Finally, given the necessary simplified language and narrative of these educational videos, complex phenomena associated with the actual behaviour of buildings under earthquakes might have been overlooked. Therefore, future work should complement these basic videos with media targeting advance knowledge and a higher level of detailing.

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The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the authors. **Ethics Committee Number**: Yaşar University Ethics Commission, 31.01.2023-03.

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APPENDICES

Appendix 1: Full Survey Questionnaire

Table 10. *Full questionnaire used for knowledge and validation surveys*

Video		Question
Video # 1: Natural Period of Buildings	1	What is an earthquake?
	2	What are seismic waves?
	3	What are ground motions?
	4	How ground motions affect buildings?
	5	What is the natural period of a building?
	6	What are the factors that influence the natural period of a building?
Video # 2: Lateral Force-Resistant Systems	7	Why vertical continuity is fundamental to provide buildings with adequate resistance to earthquakes?
	8	Why seismic resistance must be provided in both orthogonal plan directions?
	9	What are the most common seismic-resisting systems used in buildings?
	10	What is the most effective seismic-resisting system?
	11	What is the least effective seismic-resisting system?
	12	What are the most common configurations of braced frames?
Video # 3: Diaphragms and Openings	13	Which structural elements in buildings are considered as diaphragms?
	14	What is the role of a diaphragm in providing seismic resistance to buildings?
	15	Why openings might jeopardize the structural integrity of a diaphragm?
	16	From a seismic-resistance perspective, where is the worst location to make openings in the diaphragm?
	17	From a seismic-resistance perspective, where is the best location to make openings in the diaphragm?
	18	Why discontinuity of the diaphragm might lead to excessive deformations in the structure during earthquakes?
Video # 4: Building Configuration Irregularities - Part 1: Torsion	19	What is Centre of Mass?
	20	What is Stiffness?
	21	What is Centre of Resistance?
	22	What is Eccentricity?
	23	How does eccentricity affect the torsional behaviour of a building during an earthquake?
	24	Why placing the seismic-resistant elements symmetrically in plan is the best way to avoid building torsion?
Video # 5: Building Configuration Irregularities - Part 2: Irregular Plans & Pounding	25	What are regular and irregular building plan layouts?
	26	Why irregular plan layouts can be potentially dangerous during earthquakes?
	27	What is the main benefit of separating volumes of irregular building configurations using a gap?
	28	In practice, how wide should the seismic gap be?
Video # 6: Building Configuration Irregularities - Part 3: Short Columns & Soft Storey	29	What is a short column?
	30	In which situations short column mechanisms tend to appear in buildings?
	31	What design solutions help to prevent short columns mechanisms in buildings during earthquakes?
	32	Why short column mechanisms are dangerous?

	33	What is a soft storey?
	34	Why soft storey mechanisms are dangerous?
	35	Why in Türkiye buildings with soft storeys are very common?
Video # 7: Non-structural Elements - Infill Walls	36	What is the most common type of non-structural infill wall used in Türkiye?
	37	What are the negative effects of using infill walls directly connected to the structural frames?
	38	What type of damage appears when infill walls resist in-plane inertia forces?
	39	What type of damage may appear when infill walls are subjected to out-of-plane forces?
	40	Why separating infill walls from the structural frames by a gap significantly reduces the possibility of non-structural damage during an earthquake?

Appendix 2: Most frequent question-to-be-answered per video

Table 11. *Most frequent question-to-be-answered per video, in each survey*

question	survey	%	all answers			only tested answers			key answers			delta		
			$\bar{x}$	M_d	M_o	$\bar{x}$	M_d	M_o	$\bar{x}$	M_d	M_o	$\bar{x}$	M_d	M_o
Q1	S1		2.75	3	3	-	-	-	-	-	-	-	-	-
	S2-1		2.71	3	3	-	-	-	-	-	-	-	-	-
	S2-2	63	2.73	3	3	2.71	3	3	2.54	3	3	-0.17	0	0
	S3	82	2.69	3	3	2.70	3	3	2.75	3	3	0.05	0	0
Q7	S1		1.75	2	2	-	-	-	-	-	-	-	-	-
	S2-1		2.08	2	2	-	-	-	-	-	-	-	-	-
	S2-2	37	2.24	2	3	2.47	3	3	2.16	2	2	-0.32	0	0
	S3	33	2.10	2	2	2.33	2	3	2.27	2	3	-0.15	0	0
Q17	S1		1.18	1	1	-	-	-	-	-	-	-	-	-
	S2-1		2.24	2	3	-	-	-	-	-	-	-	-	-
	S2-2	25	2.22	2	2	2.62	3	3	2.23	2	3	-0.38	0	0
	S3	27	2.31	2	3	2.67	3	3	2.67	3	3	0.20	0	0
Q19	S1		2.49	3	3	-	-	-	-	-	-	-	-	-
	S2-1		2.65	3	3	-	-	-	-	-	-	-	-	-
	S2-2	64	2.61	3	3	2.59	3	3	2.41	3	3	-0.18	0	0
	S3	60	2.51	3	3	2.52	3	3	2.11	2	3	-0.41	0	0
Q26	S1		1.90	2	2	-	-	-	-	-	-	-	-	-
	S2-1		2.41	3	3	-	-	-	-	-	-	-	-	-
	S2-2	43	2.37	2	3	2.32	2	2	2.00	2	1	-0.41	0	-1
	S3	40	2.43	3	3	2.47	3	3	2.21	3	3	-0.25	0	0
Q29	S1		1.86	2	2	-	-	-	-	-	-	-	-	-
	S2-1		2.45	3	3	-	-	-	-	-	-	-	-	-
	S2-2	46	2.61	3	3	2.61	3	3	2.22	2	3	-0.24	0	0
	S3	38	2.55	3	3	2.67	3	3	1.89	2	2	-0.76	-1	-1
Q36	S1		2.06	2	2	-	-	-	-	-	-	-	-	-
	S2-1		2.22	2	2	-	-	-	-	-	-	-	-	-
	S2-2	53	2.37	3	3	2.64	3	3	2.46	3	3	-0.26	0	0
	S3	43	2.31	2	3	2.63	3	3	2.68	3	3	-0.07	0	0

Appendix 3: Interview Questions

During the past statics course, assignment no. 5, you and your teammates were requested to watch a video, prepare physical models and then make a presentation with them in class:

Video

- Do you remember which video was it?
- can you describe it?
- what was the main goal of that video?
- how long was that video?
- was the video spoken in English or Turkish?
- did this help or not?
- Was there anything special or important in the video?
- Was there anything that drew your attention?
- Or something you really liked about the video?
- Something you disliked?

Working

- how was the experience of working with that video as source of information/inspiration to prepare the models?
- could you understand how to build your model from this and/or other videos?
- If yes, which part of the video helped you the most to make the model?
- If not, how did you figure it out the construction/assemble of the model?
- Was it easy or difficult to make the model?
- Why?

Testing

- Could you and your teammates repeat the behaviour of the model as showed in the videos?
- were you able to explain that behaviour?
- Which part of the testing/presentation was very close to the way is presented in the video?
- was there something missing, e.g. something that appeared in the video but was not repeated in the presentation?
- Was there something that went wrong during your presentation/testing?

Learning

- do you feel you learned something during this exercise/process?
- if so, what?
- did you learn more from watching the videos, making the model, or testing the model? - answer from more to less
- what things you could not understand/learn?
- (only if previous question is answered) What was the main obstacle for you to understand/learn that?

Suggestion

if the exercise is repeated in the future:

- would you suggest to focus only on videos, working only with models, or a combination of both?
- what would you repeat?
- what would you do differently?

Learning Process

- Do you think this exercise contributed to your knowledge about earthquakes?
- If the information conveyed through videos was explained not in videos but with physical lectures, which one do you think would attract more your attention? Why?
- Did the colours used in the videos, the use of signs in certain places and the highlighted information affect your focus on the subject? How? Did they affect your understanding of the subject? How? Can you provide an example of this?
- As you may have noticed, long topics (e.g. building configuration irregularities) were subdivided in two or three short videos. Did this make it easier for you to follow and understand the information described in there?
- Was it helpful for you to remember/learn the knowledge by watching the videos over and over in the model making tasks given after the videos? Did it contribute to the model making process? Did it provide you flexibility for your working pattern?

Final Question

Is there anything you would like to add?