1 Increasing Earthquake Awareness: Seismo-at-school Switzerland

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14 **Abstract.** The *Increasing Earthquake Awareness in Switzerland* project set out to connect students, teachers, and the wider

15 public with earthquake science by reviving and extending the nationwide *seismo@school* initiative. Supported by the Swiss

16 National Science Foundation (SNSF) AGORA programme, the project developed a suite of multilingual teaching resources,

17 deployed near real-time seismic sensors in schools, and created hands-on activities to foster engagement of 12 to 18-year-olds.

18 Although Switzerland is exposed to only moderate seismic hazard, earthquakes remain the natural hazard with the highest

19 potential impact. Because most residents have never experienced a damaging earthquake, educational programmes play a

20 crucial role in raising awareness and strengthening preparedness. Moreover, *seismo@school* initiatives can inspire younger

21 generations to pursue geosciences by helping them appreciate the relevance of the field. This article presents the rationale,

22 implementation, and impact of the project, and may serve as a guide for other countries seeking to develop similar initiatives.

23 It examines how experiential, data-driven educational approaches can improve earthquake awareness and preparedness in

24 moderate-hazard regions, how school-based seismometers benefit both teaching and scientific monitoring while considering

25 the practical challenges of installation and operation, and what institutional and policy conditions are required to sustain such

26 efforts over the long term.

1 Introduction

28 Although Switzerland is not among the most seismically active regions in the world, earthquakes remain an underestimated

29 risk. Historical events such as the Basel earthquake of 1356 (Mw ~6.6) and the more recent 1946 Sierre earthquake (Mw 5.8)

30   - still recalled by some of the local population - highlight the hazard in a country where damaging earthquakes occur roughly

31   every 100 to 150 years (Wiemer et al., 2016; Fäh et al., 2011). National hazard models show overall moderate seismicity, with

32   the highest hazard in Valais, followed by Basel, Grisons, Central Switzerland, the St. Gallen Rhine Valley, and the rest of

33   Switzerland. Earthquakes represent the natural hazard with the greatest potential to cause casualties and economic losses in

34   Switzerland (FOCP, 2026; Wiemer et al., 2023). However, because few inhabitants have ever felt strong shaking, either

35   domestically or abroad, public awareness and preparedness remain low (Dallo et al., 2022a).

36   Although seismic hazard in Switzerland is moderate, strong earthquakes will occur again, and preparedness will be a major

37   advantage. Educational initiatives play a crucial role in building community resilience by embedding knowledge of earthquake

38   processes, hazard, and risk into school curricula and public discourse. International experience shows that citizen seismology

39   and educational seismology (*seismo@school*) programmes are particularly effective for engaging with the public and spreading

40   knowledge in earthquake prone countries (e.g., Chen et al., 2020). They also help motivate younger generations to study

41   geosciences, even in regions where earthquakes are less common (e.g., Denton et al., 2018). Key examples include the SISMOS

42   à l'École network in France, which has successfully run for over 25 years and is now formally integrated into the national high

43   school curriculum (Berenguer et al., 2020; Courboulex et al., 2012); the UK School Seismology Project (Butcher et al., 2011;

44   Denton et al., 2008), run by the British Geological Survey; the European EDUSEIS initiative (Zollo and Bobbio, 2000; Cantore

45   et al., 2003); and the long-running U.S. IRIS Seismographs in Schools programme (Braile et al., 2003). The success of these

46   programmes has been driven often by installation of low-cost seismometers at schools, as demonstrated, for example, in Nepal

47   (Subedi et al., 2020a, 2020b), Australia (AuSIS; Mousavi et al., 2022), Ukraine (Amashukeli et al., 2024), New Zealand

48   (CRISiSLab Challenge; Tan et al., 2022), Ireland (QuakeShake; https://quakeshake.ie/home/, last accessed November 2025),

49   or at Yale University (Löberich and Long, 2024).

50   Building on this international experience, a temporary project in Switzerland (Sornette and Haslinger, 2009), as well as on the

51   implementation of an educational seismology project in Nepal (Subedi et al., 2020a) by the University of Lausanne (UNIL),

52   the first phase of *seismo@school* in Switzerland was launched in 2021 in the French-speaking cantons of Vaud and Valais.

53   Over two years, a network of schools and school seismometers was established, led by UNIL, the University of Applied

54   Sciences and Arts in the Valais region (Haute École Spécialisée de Suisse Occidentale Valais-Wallis, HES-SO Valais-Wallis),

55   and the Earthquake Prevention Learning Centre (Centre de Prévention des Séismes, CPPS) in Sion.

56   To make this initiative a national programme, these institutions joined forces with the Swiss Seismological Service (SED) at

57   ETH Zurich (ETHZ) and other partners, which played a central role in expanding the network and offering further scientific

58   and operational expertise. Led by the SED, they launched the *Increasing Earthquake Awareness in Switzerland* project in May

59   2023 (Dallo et al., 2023; Böse et al., 2024a; Hetényi et al., 2025). This 2-year project aimed to revitalise and expand

60   *seismo@school Switzerland* by supplying schools with updated comprehensive educational resources reflecting current

61   knowledge in seismology and related fields, classroom Raspberry Shake seismometers for earthquake recording, and direct

62 connections to active research. Additional objectives included strengthening STEM education and addressing the declining
63 number of students pursuing Earth Sciences and related fields as future career paths.

64 In this paper, we investigate how experiential, data-driven educational approaches can enhance earthquake awareness and
65 preparedness in moderate-hazard regions; how school-based seismometers support both teaching and scientific monitoring
66 while introducing practical challenges regarding installation and operation; and what institutional and policy conditions are
67 necessary to sustain such efforts over the long term. We first present the project components and their implementation,
68 including the development and dissemination of multilingual teaching materials on earthquake-related topics. We then examine
69 the benefits and limitations of deploying low-cost seismometers in schools, followed by the introduction of a student-
70 assembled seismometer kit designed to familiarise students with basic monitoring principles and foster engagement. In the
71 next section, we outline the methods and results of a survey conducted with teachers at participating schools at the end of the
72 project, which serves to evaluate the educational impact of the presented activities. Finally, we discuss the challenges
73 associated with implementation and long-term sustainability of *seismo-at-school* and propose possible pathways for future
74 developments of the initiative.

75 **2 Project Components and Implementation**

76 **2.1 Teaching Resources**

77 A central achievement of the programme was the development of a comprehensive set of teaching resources on earthquake-
78 related topics. While the official Swiss curriculum defines clear teaching objectives, existing educational materials -
79 particularly on socially relevant seismic themes - remain limited, underscoring the need for updated, multilingual, and visually
80 engaging resources aligned with the curriculum. The content of the resources was identified and developed in close
81 collaboration with scientists and teachers, beginning with an online survey to ensure relevance to classroom needs. The
82 materials were structured into five thematic modules (*General Earthquake Knowledge*, *Earthquake Monitoring and Raspberry
83 Shake*, *Seismic Hazard and Risk in Switzerland*, *Induced Seismicity*, and *Misinformation and Media Literacy*), each comprising
84 a general introduction and a Swiss-specific component. Each module combines explanatory texts with graphics and a variety
85 of interactive elements, including quizzes, experiments, and hands-on activities, expected to be completed within 1 to 2 hours.
86 The educational materials encourage active participation through practical exercises, critical thinking tasks, and real-world
87 examples, helping students connect scientific principles with everyday experience.

88 The resources can be used as stand-alone topics or complete modules, depending on curricular requirements and lesson
89 planning. This structure allows teachers to integrate the educational materials flexibly into science and geography lessons. To
90 maximise reach across Switzerland - a country with four official languages - and to facilitate international outreach, the
91 resources were translated into German, French, Italian, and English, and made available through a dedicated SED

92   *seismo@school* webpage (http://seismo.ethz.ch/en/news-and-services/for-schools/teaching-resources), last accessed
93   November 2025). The educational materials were promoted through (geography) teacher networks (e.g., online Teams groups),
94   workshops, and direct engagement with schools. The following sections provide a summary of each of the five modules.

2.1.1 General Earthquake Knowledge

96   The *General Earthquake Knowledge* module introduces the fundamental science of earthquakes, beginning with the role of
97   plate tectonics and fault movement in generating seismic activity. Students learn how stress accumulates along tectonic
98   boundaries and is released as seismic waves during earthquakes. The material explores where earthquakes occur – mostly
99   along active margins such as the Pacific *Ring of Fire*, but also in intraplate regions (such as Switzerland), volcanic zones, or
100   due to other natural phenomena and human activity triggering earthquakes. Different exercises and visual aids help illustrate
101   these geological processes and set the foundation for understanding earthquake origins.

102   A second focus of the module is the characterization and measurement of earthquakes. The differences between P-waves, S-
103   waves, and surface waves are discussed, along with concepts such as hypocentre, epicentre, magnitude, and intensity. Case
104   studies and analogies clarify how magnitude measures total energy release, while intensity captures local effects. Tools such
105   as seismograms, ShakeMaps, and early warning systems are introduced to show how scientists monitor and communicate
106   earthquake data and information to the public. These components combine theoretical knowledge with real-world applications,
107   encouraging students to interpret seismic information critically.

108   The final section addresses seismic risks, consequences, and preparedness. Students learn about direct impacts of earthquakes
109   like structural damage and casualties, as well as secondary hazards including tsunamis, landslides, and liquefaction. Emphasis
110   is placed on practical safety strategies such as earthquake resistant construction, earthquake insurance as well as
111   recommendations for actions to be taken *before*, *during*, and *after* a strong earthquake. Through exercises and scenario-based
112   tasks, students apply this knowledge to both Swiss and international contexts, raising awareness of earthquakes and their effects
113   while strengthening society's resilience.

2.1.2 Earthquake Monitoring and Raspberry Shake

115   The *Earthquake Monitoring and Raspberry Shake* module traces the history of earthquake detection from early instruments,
116   such as Zhang Heng's seismoscope, to today's highly sensitive electromechanical devices. Students are introduced to the Swiss
117   National Seismic Network, which includes over 200 permanent monitoring stations across the country operated by the SED.
118   A simple method is introduced to demonstrate how earthquakes can be located via triangulation, which uses differences in P-
119   and S-wave arrival times at various stations. By analysing seismograms and applying simple formulas, students gain hands-on
120   insight into this method and also learn why triangulation is not used in professional seismic monitoring.

121   The second part of the module focuses on Raspberry Shake seismometers, which are affordable and user-friendly devices to

122   record earthquakes mostly for non-professional use. In the scope of our *seismo@school* initiative, we deployed Raspberry

123   Shake seismometers in 46 Swiss schools (see **Figure 1**, **Chapter 2.2**). Students learn how geophones in the devices convert

124   ground vibrations into digital signals, which can then be visualized, for example, through the Raspberry Shake webpage

125   (https://stationview.raspberryshake.org/), allowing real-time exploration of seismograms, spectrograms, and daily helicorder

126   plots. The exercises highlight how everyday seismic *noise*, such as traffic, concerts or variable-frequency sources (helicopter,

127   washing machine), also appears in recordings, helping students distinguish natural from human-induced vibrations.

128   To extend the learning, students engage with programming and data analysis using a Jupyter Notebook. This environment

129   allows them to process and interpret recordings from the Swiss school network, familiarizing them with basics of scientific

130   programming. By connecting classroom learning to live data and real monitoring tools, the module combines theoretical

131   seismology with practical, technology-driven investigation. It provides an authentic experience of how earthquakes are

132   monitored, recorded, and data interpreted, while also encouraging students to conduct their own scientific projects.

133   **2.1.3 Earthquake Hazard and Risk in Switzerland**

134   The *Earthquake Hazard and Risk in Switzerland* module introduces the key concepts of earthquake hazard and risk,

135   emphasizing the distinction between natural probability and human vulnerability. *Hazard* refers to the likelihood or probability

136   of earthquakes occurring in a specific region, whereas *risk* describes the potential consequences or impacts these events may

137   have on people, infrastructure, and society. Using everyday analogies, students see how external events are unavoidable, yet

138   how preparedness and resilience influence outcomes. The module offers different exercises using Switzerland's seismic hazard

139   and risk maps to help students better understand the two terms.

140   Following the general introduction, the module examines the distribution of earthquake risk across Switzerland, showing how

141   urban areas like Basel, Geneva, Zurich, and Bern face higher risk due to dense populations and concentrated assets (Wiemer

142   et al., 2023). Historical examples, such as the 1356 Basel earthquake, illustrate how the consequences of seismic events vary

143   over time, reflecting differences in urban development, construction standards, and possibly societal preparedness between

144   past and present contexts. Earthquake scenarios for various Swiss cities illustrate the potential damage in terms of building

145   damage costs, fatalities, the number of people seeking shelter, and other key indicators of societal disruption (Marti et al.,

146   2023). By comparing different scenarios and conducting an exercise using the SED *Earthquake Risk Tool*

147   (www.seismo.ethz.ch/earthquake-country-switzerland/risk/earthquake-risk-tool/, last accessed November 2025), students

148   analyse and discuss the various factors influencing risk in detail. Finally, the Swiss case is set within global and European

149   contexts (Danciu et al., 2021; Crowley et al., 2021). Comparisons with higher-hazard regions in southern Europe highlight

150   Switzerland's moderate hazard but significant risk due to infrastructure density. Interactive mapping tools from European

151 (www.efehr.org, last accessed November 2025) and global hazard and risk models (https://www.globalquakemodel.org/, last
152 accessed November 2025) invite students to explore worldwide variations.

2.1.4 Induced Seismicity

154 The *Induced Seismicity* module examines how human activities – such as mining, dam construction, fracking, wastewater
155 injection, CO_2 storage, and deep geothermal energy projects – can trigger earthquakes (e.g., Moein et al., 2023). Although
156 most induced events are small and pose minimal risk, some have caused significant damage, raising important safety and risk
157 management concerns (Grigoli et al., 2017). Over recent decades, induced seismicity has become an increasingly prominent
158 multidisciplinary field of research, integrating perspectives from engineering, geology, and social sciences (e.g., Paluszny et
159 al., 2024). At the same time, these phenomena continue to provoke public and political debate. The module specifically
160 investigates induced seismicity in the context of deep geothermal energy, exploring it through multiple disciplinary and societal
161 lenses.

162 The module situates geothermal energy within Switzerland's national climate strategy, emphasizing its potential contribution
163 to achieving net-zero emissions by 2050. Students examine the principles and applications of deep geothermal energy,
164 exploring both the opportunities and challenges associated with petrothermal and hydrothermal systems. These concepts are
165 illustrated through Swiss case studies, including Basel (2006) and St. Gallen (2013) projects (Mignan et al., 2015; Diehl et al.,
166 2017), where induced earthquakes ultimately led to the cancellation of geothermal operations, underscoring the complex
167 balance between renewable energy development and seismic risk management.

168 Classroom exercises include role-play debates, allowing students to adopt the perspectives of stakeholders such as residents,
169 authorities, environmental organisations, and energy companies. These activities foster discussion on balancing sustainable
170 energy development, public acceptance, and safety. By linking scientific understanding with social decision-making, the
171 module underscores the interdisciplinary nature of earthquake risks and energy policy.

2.1.5 Misinformation and Media Literacy

173 The *Misinformation and Media Literacy* module examines the dissemination of earthquake-related misinformation and fosters
174 students' critical media literacy. It clarifies the distinctions between misinformation, disinformation, fake news, and conspiracy
175 theories, enabling students to critically assess information sources and understand how inaccurate narratives can shape public
176 perception and responses (Dallo et al., 2022b). Furthermore, the module provides insight into why false information is spread,
177 both consciously and unconsciously, and analyses how social media, messaging apps, and online platforms amplify its spread,
178 particularly in the aftermath of disasters. Real-world cases from the 2023 Türkiye-Syria and the 2023 Morocco earthquakes
179 illustrate these dynamics.

180 The module also addresses common earthquake myths. Students are presented with current knowledge on earthquake causes,
181 forecasting, and induced seismicity, and are required to apply this knowledge through practical exercises. By contrasting
182 misinformation with scientific explanations, students are encouraged to critically evaluate claims and to recognise the
183 boundaries of current understanding.

184 The final section focuses on developing practical media literacy skills. Exercises extend beyond the context of earthquakes
185 and promote transferable competencies for navigating digital information. This module helps students become better equipped
186 to identify misinformation, understand its psychological appeal, and take responsibility for how they share and interpret
187 information online.

2.2 Raspberry Shake School Network Switzerland

189 A second key element of the programme was the expansion of the *seismo@school* Raspberry Shake school network across
190 Swiss schools. In the earlier SNSF-funded initiative, UNIL and CPPS installed 23 vertical-component (1D) Raspberry Shake
191 geophones in the French-speaking cantons of Vaud and Valais, identified through newsletters from the cantonal Education
192 Departments. With the new *Increasing Seismic Awareness in Switzerland* project, we were able to expand this network to 46
193 secondary schools nationwide.

194 In Switzerland, the Swiss Seismological Service (SED) at ETH Zurich holds the official mandate for seismic monitoring and
195 providing the public with earthquake information and warnings (Böse et al., 2024b). To fulfil this role, the SED operates a
196 dense nationwide network composed of different modern seismometers and integrates near real-time data streams from
197 neighbouring countries (Clinton et al., 2011; Cauzzi & Clinton, 2013; Diehl et al., 2025). The service is supported by
198 professional scientific and technical staff on call around the clock to analyse seismic data and ensure reliable network and
199 infrastructure operations. Given this framework, it is natural to incorporate the *seismo@school* Raspberry Shake instruments
200 into the SED's monitoring infrastructure, despite their clear limitations compared to the high-quality sensors and digitizers
201 normally deployed. The school-based devices are significantly noisier – especially during daytime hours when students and
202 teachers are active in the buildings where they are installed – and occasionally underperform in time accuracy. However, care
203 has been taken in their installation to avoid excessive noise.

204 A critical aspect of integrating the Raspberry Shake into the Swiss seismic network was maintaining control over the data
205 flow. One of the main advantages of using Raspberry Shake instruments is their ease of setup and seamless integration into
206 the Raspberry Shake ecosystem. However, this convenience comes with limitations: data is routed through Raspberry Shake
207 servers and station names are constrained by their system. Also, the system may fail at any time and has failed in the past. To
208 ensure full control of data flow and management, all Raspberry Shakes included in the *seismo@school Switzerland* project
209 have a secondary stream to SED-ETHZ running a proprietary, but simple UDP protocol designed by Raspberry Shake. Data

210 is received by a seedlink plugin written by SED-ETHZ which converts the incoming data according to SED standards in respect

211 to network, station, location and channel naming as well as miniseed formatting. It is then incorporated into established

212 workflows for monitoring, archiving, distribution, and processing. In parallel, the data also continue to flow to the Raspberry

213 Shake servers, ensuring full availability within their system.

214 At the start of the project, we integrated the existing 1D Raspberry Shake school seismometers in Vaud and Valais into the

215 SED monitoring infrastructure. In parallel, we identified new schools in other cantons from a survey conducted at the start of

216 the project, using comprehensive email lists available at ETH Zurich. Schools expressing interest in hosting a Raspberry Shake

217 were contacted via email with details on participation requirements. Once a school had accepted these conditions, we shared

218 a detailed installation guide covering location selection, network configuration, sensor setup, and operation. We asked the

219 schools to install the Raspberry Shake sensor directly on the ground, on a firm and level surface, away from vibration sources

220 and ideally near a room corner. Installation in a basement and within a small building is preferable. The sensor should be

221 connected to power and Ethernet and configured via a web interface with site details, data forwarding, and the SED-ETHZ

222 server IP (preconfigured by us with the Raspberry Shake-specific port). Data should be sent to both the Raspberry Shake server

223 and the SED-ETHZ server. For 3-component seismometers, the device should be oriented to north, levelled, and secured in

224 place with cables marked to prevent movement. Schools were requested to document the installation, including site

225 coordinates, building details, and photos, and send this information back to us. Most schools identified their sub-basements or

226 server rooms as suitable locations, as these rooms are rarely used and generally have the necessary infrastructure. Schools in

227 Vaud and Valais also favoured the school library or temporary teaching rooms, where students could more easily access the

228 Raspberry Shakes with their teachers for in-class activities. We recommended teachers not to move the stations for teaching

229 purposes, and this was very well respected.

230 For the initial installations, we visited schools in person to assist with setup, familiarize ourselves with the process, and identify

231 potential issues to provide better guidance for subsequent schools. At later stages, when we were confident our documentation

232 was sufficient to allow independent high-quality installations, we shipped the Raspberry Shake units by post. Before shipping,

233 the standard SD cards in each unit were replaced with high-quality, industrial-grade 16 GB microSD cards, since SD cards are

234 a common point of failure, particularly when the system is not properly powered down before unplugging. Each Raspberry

235 Shake was also preconfigured with the appropriate port information, ensuring a straightforward setup process upon arrival.
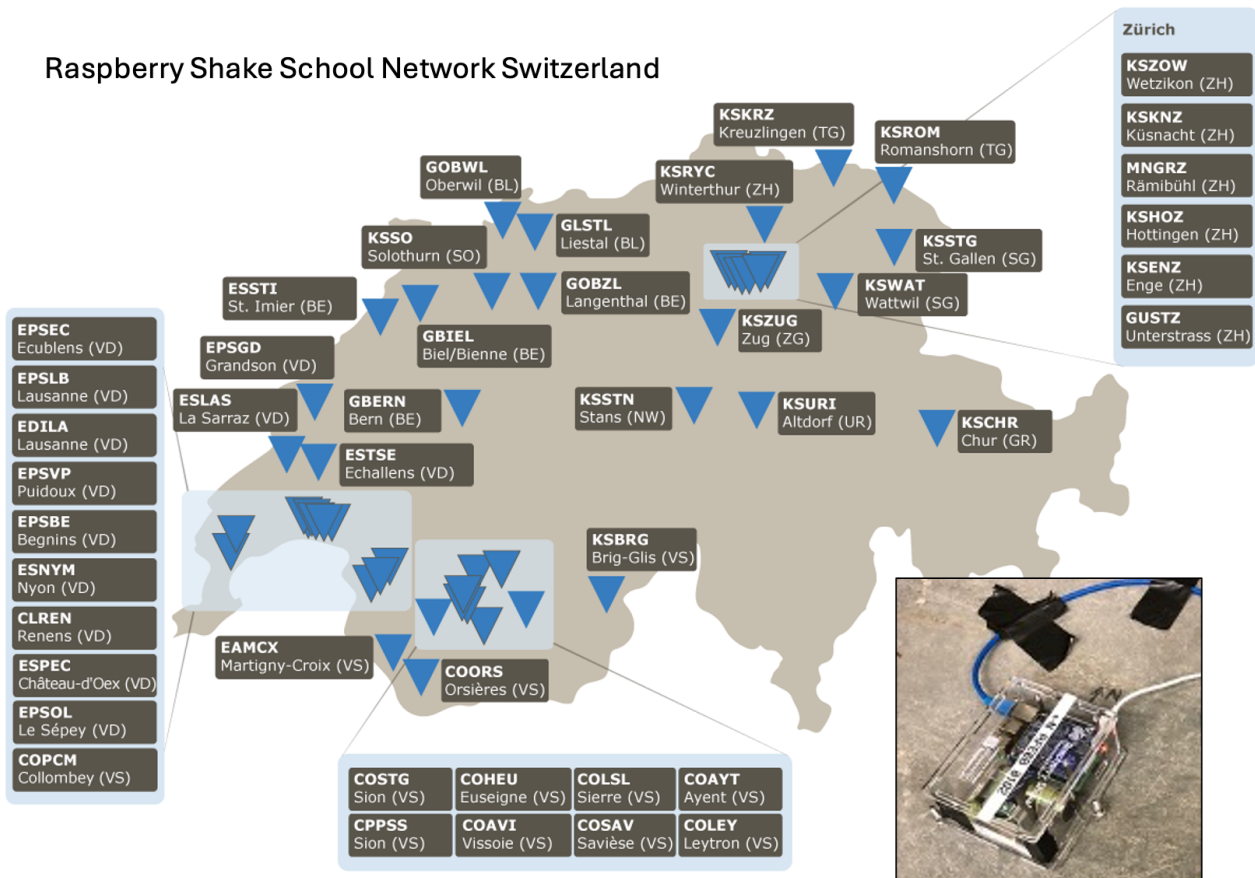
236 A common challenge was ensuring that the Raspberry Shake could communicate continuously with the SED-ETHZ server

237 through the school's network. Some schools experienced firewall restrictions that blocked outgoing or incoming connections

238 required for data transmission. To address this, we provided detailed instructions on server and port configuration. Schools

239 were encouraged to work with their IT departments to verify that the Ethernet connection could reach external servers without

240 interruption. In some cantons, school IT is centrally managed by the Education Department, which requires additional

241 coordination to overcome firewall issues. Unfortunately, firewall settings at many schools are reset during vacation periods,

which can temporarily block Raspberry Shake data transmission. To mitigate this, schools were advised to check connectivity after holidays and, where possible, to coordinate with IT administrators to implement persistent firewall rules or automated reconnection procedures. This, however, remained a challenge throughout the project.

Over a period of two years, we were able to install an additional set of 23 3-component (3D) Raspberry Shake geophones in secondary schools across Switzerland (**Figure 1**). While we initially contacted schools based on our survey, interest spread quickly, and additional schools reached out to participate. Due to the limited funding, we could not accommodate all requests and had to be selective, also considering the need for a well-balanced network across the country. Schools that were unable to receive a sensor were offered the option to collaborate with nearby participating schools or to purchase their own seismometer, which could then be integrated into the *seismo@school* network; to date, this has been realized by one school in the canton of Lucerne. Despite several attempts, we have not yet been able to identify a suitable school in the canton of Ticino, in the Italian-speaking part of Switzerland.

Figure 1: The Raspberry Shake school network Switzerland, as of today including 46 seismometers, deployed in secondary schools throughout the country.
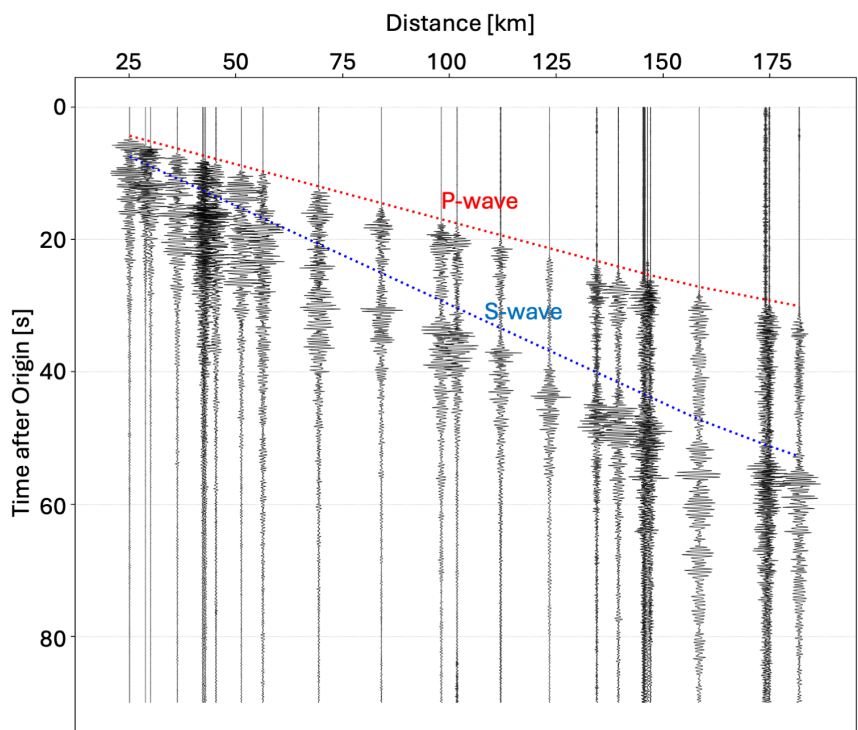
256 Students, teachers, and other users have unrestricted access to data from the Raspberry Shake stations. Data can be accessed
257 via multiple platforms, including the Raspberry Shake DataView webpage, the ShakeNet mobile app, and the SED website.
258 The project has a fully open data policy (see **Data and Resources**). For advanced users, such as students working on school
259 projects, we provide a Jupyter notebook with example codes demonstrating how to access data through FDSN web services
260 and how to visualize it. Our teaching module *Earthquake Monitoring and Raspberry Shake* (see **Chapter 2.1.2**) provides
261 further guidance. To engage students and raise awareness of a newly installed Raspberry Shake, we encouraged schools to
262 start with interactive experiments, such as gathering students around the sensor or in a neighbouring room to perform jump
263 tests, for example with an increasing number of students, or by one person and decreasing distance to the seismometer. Several
264 schools have also announced the Raspberry Shake installation in internal newsletters to promote interest and participation.

265 Power Spectral Density (PSD) analysis, computed daily at the SED for all stations (see **Data and Resources**), provides a
266 quantitative framework for assessing the quality of seismic data from both high-quality SED stations and Raspberry Shake
267 school seismometers. PSDs measure how seismic signal power is distributed across frequencies, allowing separation of natural
268 seismic signals from anthropogenic noise. High-quality SED stations exhibit low, stable noise across both low frequencies
269 (<0.1 Hz, e.g., microseisms) and higher frequencies (>1 Hz). In contrast, Raspberry Shake school seismometers show elevated
270 noise above ~1 Hz during school hours, caused by human activity, footsteps, and machinery. Lower-frequency signals (<0.1
271 Hz) are generally more reliable, but low-cost Raspberry Shake instruments are not optimal for measuring very long-period
272 signals (e.g., periods >20–30 s) due to instrumental limitations. In general, above 1 Hz, the school seismometers are at or
273 below the Peterson high-noise model (Peterson, 1993), and some stations are well below this level.

274 Despite their limitations, we found that the Raspberry Shake seismometers can generally detect local earthquakes of magnitude
275 2.5 and larger at distances of up to ~330 km – consistent with observations by Subedi et al. (2020) – , as well as moderate- to
276 large-magnitude regional and teleseismic earthquakes, often even during noisy school days and more consistently at night, on
277 weekends, or during school vacations (**Figure 2**). Although their primary purpose remains educational, yet the school
278 seismometers have also proven scientifically valuable. While, by choice, they are not used for trigger-based detection or
279 standard automatic locations at the SED, they are integrated into automated event-based machine-learning re-location
280 pipelines, and 3-component station amplitudes contribute to automatic magnitude estimates. Additionally, the school sensors
281 are used in manual solutions for picking P and S phases, determining P-wave polarity and magnitude. They are often important
282 stations as they fill data gaps for depth estimation, focal mechanisms, and tomography. Notable events include a magnitude
283 (MLhc) 3.0 earthquake near Zürich (Affoltern am Albis, July 30, 2025) and a series of small earthquakes near Ebnat-Kappel
284 (June 2025), where Raspberry Shake seismometers provided valuable data, in particular for depth determination. Recently, the
285 detection of a suspicious signal at a Raspberry Shake school sensor in the canton of Vaud in October 2025 even triggered the
286 search for a meteorite crossing the sky that induced ground vibrations across western Switzerland (Kraft et al., in prep.).
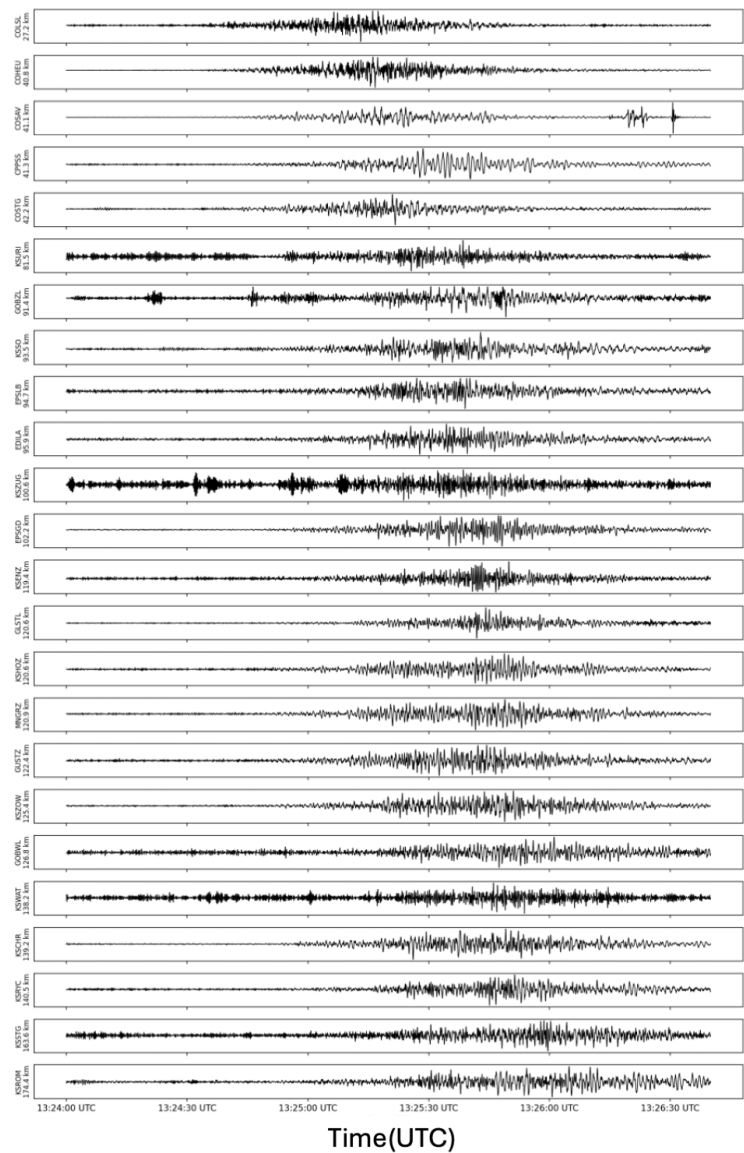
Figure 2: Raspberry Shake school network recordings of the local 2024 magnitude (MLhc) 4.4 Sihltal earthquake. Red and blue dashed lines mark theoretical P- and S-wave arrival times based on the regional velocity model.

The Raspberry Shake school network allows students to monitor real-time seismicity directly from their classrooms, fostering a sense of ownership and engagement through active participation. Schools can investigate both local and global earthquakes using data from their own instrument and undertake small research projects – for example, as part of a *Matura* thesis, an independent research project carried out during the final year of upper secondary school in Switzerland (*Gymnasium*, *Lycée*, or *Liceo*). An important aspect of the Raspberry Shake is that they can record all types of vibrations, not just those from earthquakes. This includes traffic, sonic booms, concerts (e.g., the *Swift quakes* during a Taylor Swift concert in Zurich), and landslides. Mass movements are of particular interest in Switzerland, where their frequency has increased over the last decade, probably as a result of climate change. For example, a massive mass movement occurred in Blatten in Valais in southern Switzerland on 28 May 2025, equivalent to a magnitude (MLhc) 3.1 earthquake. Although this event occurred during school hours, it was well recorded by the entire Raspberry Shake school network across Switzerland beyond 175 km distance (**Figure 3**). Schools found this particularly impressive, partly due to the strong media coverage, and the event was frequently used in lessons to discuss mass movements in the context of climate change and its impacts on Switzerland.
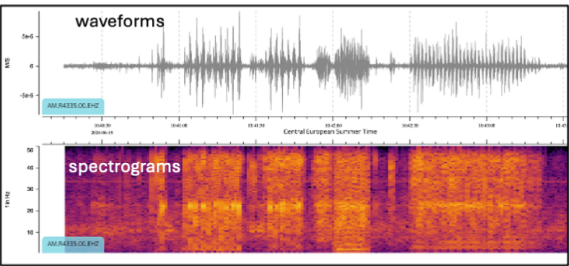
Figure 3: Left: Raspberry Shake school network recordings of a massive mass movement occurred in Blatten in Valais in southern Switzerland on 28 May 2025, equivalent to a magnitude (MLhc) 3.1 earthquake. Right: 'Jumping tests' help students understand how seismometers record seismic events (© Marion Loher).

2.3 Exploratory Activities

To introduce students to the principles of earthquake detection, we created as a third key outcome of the project a compact do-it-yourself seismometer kit for schools, the *Lambda Slinky Seismometer* (**Figure 4**), named for its distinctive shape. The seismometer consists of a wooden base supporting a homemade coil, a load, and a box containing an Arduino and a screen
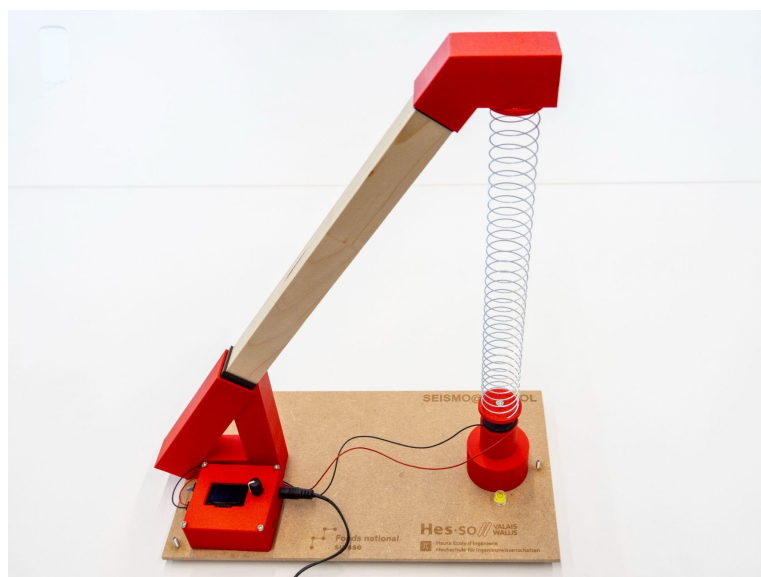
310 displaying real-time measurements. A gallows structure holds a Slinky spring with two magnets: one serving as the measuring
311 element and the other for centring and damping. The instrument is designed to record both seismic events and classroom jump
312 experiments. By turning a knob on the display unit, users can access the ten most recently recorded events, each showing the
313 corresponding date and time.

314 The housing and mechanical components can be 3D-printed, while the electronic parts are standard and readily available
315 online. The Arduino-based processor can easily be reprogrammed by teachers or students, allowing for further experimentation
316 and adaptation to classroom needs. The device can be assembled in roughly 30 minutes with the support of a step-by-step
317 video tutorial (http://static.seismo.ethz.ch/sedvideos/seismo_school/tutorial_de.mp4, last accessed November 2025), making
318 it accessible even for beginners. Once built, the seismometer reacts to small ground vibrations, such as footsteps or jumps, and
319 displays the resulting signals in real time on an Arduino screen.

320 Although the kit is not intended for scientific research, it provides an engaging and tangible demonstration of how seismic
321 instruments work. By letting students see their own movements converted into measurable signals, it bridges abstract concepts
322 of ground motion with a hands-on learning experience. This playful approach captures curiosity while reinforcing the physical
323 principles behind seismology. The project benefits from the so-called *IKEA effect*: learners feel greater attachment and
324 motivation when they build the tool themselves, turning assembly into an integral part of the educational journey. By owning
325 a physical device, the *IKEA effect* is most likely even stronger than owning "data" from one's school seismometer. Around 20
326 kits have been distributed to schools across Switzerland so far, expanding opportunities for classroom experiments.

327

Figure 4: The *Lambda Slinky Seismometer* kit (here already assembled) for schools developed during the *seismo@school Switzerland* project.

2.4 Teacher, Student and International Engagement

The educational resources developed during the project were promoted and disseminated through teacher networks and educational events, reaching not only participating schools but also those without a seismometer. We organized several online and in-person workshops, engaging approximately 60 teachers in total, to familiarize them with the new educational materials and the Raspberry Shake seismometers. These workshops provided valuable opportunities for direct exchange with teachers, allowing us to gain insights into everyday school practices. Furthermore, we obtained a clearer understanding of the teachers' existing knowledge – what they already master and where gaps remain. Conversely, the teachers valued the opportunity to discuss their questions directly with experts and to gain insights into ongoing research projects. As a result of these workshops, additional schools contacted us, expressing interest in joining the *seismo@school* initiative. During these workshops and through follow-up email communication teachers were guided also on how to access and interpret Raspberry Shake data. For significant seismic events, we continue to provide seismograms and contextual background information. A recent survey indicated that many teachers have actively used these materials in their classrooms to discuss seismic events with students.

Beyond workshops, student visits to ETH Zurich and the supervision of Matura theses provided opportunities for motivated pupils to conduct original analyses. For example, one student developed a Dash app that visualizes data from the Raspberry Shake school seismometers for selected local earthquakes and provides an approximate animation of P- and S-wave propagation (http://sas-viewer.ethz.ch/, last accessed November 2025). School classes can also visit *focus*Terra at ETH Zurich or the CPPS in Sion to complement their classroom learning with interactive exhibits on earthquakes and seismic phenomena. Both locations feature earthquake simulators that reproduce ground shaking, allowing students to experience earthquakes in an immersive and safe environment. Such simulators allow students to feel the ground motion associated with different earthquakes – an experience that is especially valuable in Switzerland, where large earthquakes are rare. By combining the direct physical experience with scientific explanations, these visits create a powerful and memorable learning experience that bridges theoretical understanding and real-world perception of seismic phenomena.

At the international level, our team actively engaged with the global educational seismology community. To exchange ideas we conducted two online meetings in 2025 with participants from ten countries, including France, United Kingdom, Ireland, Ukraine, Germany, Nepal, New Zealand, Ecuador, and the United States of America. To further strengthen global partnerships, the team supported in April 2025 the 5th International Workshop on Educational Seismology in Nepal and its associated Earthquake Learning Exhibit (Subedi et al., 2025), organized to commemorate the 10th anniversary of the 2015 magnitude 7.9 Gorkha earthquake. The exhibition comprised 14 interactive modules, covering topics such as tectonic processes, seismic waves, building construction, and practical, location-based safety guidance on what to do *before, during, and after* an

359 earthquake, as well as the installation of a seismometer. Approximately 2,000 pupils participated in this event. Pre- and
360 post-event surveys of several hundred participating students revealed substantial improvements in knowledge, heightened risk
361 perception, and increased intent to take preparedness actions. Subedi et al. (2025) highlight how the exhibition's experiential,
362 student-centred format effectively bridged scientific concepts and local realities to foster both individual and collective
363 preparedness through education. However, sustaining the impact will require follow-up interventions, institutionalization
364 through schools and local governance, and expanded training for teachers and volunteers. We propose that this model is
365 scalable and could serve as a replicable framework for earthquake education programmes in other vulnerable regions.
366 Regardless of the differences between Nepal and Switzerland, we aim to continue cooperation between the two countries for
367 knowledge and experience transfer in the domain of educational seismology. The educational materials and modules developed
368 during our project are currently being translated into Nepali for use within the local education system.

369 **3 Data and Methods**

370 Throughout the initiative (2023–2025), a combination of qualitative and quantitative approaches was used to monitor and
371 enhance the effectiveness of the developed activities while also providing insights into the overarching research interest (see
372 **Chapter 1**). This included two online surveys and a series of teacher workshops (May 2024, March 2025, and May 2025),
373 which offered structured opportunities to gather detailed feedback and better understand teachers' needs. Scientific accuracy
374 was ensured through reviews by experts from the relevant fields.

375 **3.1 Transdisciplinary approach**

376 The *seismo@school* initiative followed a transdisciplinary and iterative approach, bringing together teachers, partner
377 organisations with extensive experience in knowledge transfer and outreach, researchers, and communication specialists. This
378 collaborative framework ensured that all materials and activities were co-designed for practical and effective classroom use.
379 Such an approach aligns with the principles of transdisciplinary research, which focuses on the active involvement of diverse
380 stakeholders–not only scientists but also non-academic stakeholders such as teachers–who jointly frame the problems and
381 generate knowledge (Lang et al., 2012; Pearce & Ejderyan, 2020; Jahn et al., 2012)

382 **3.2 Online surveys**

383 The first online survey was conducted between July and August 2023 among 49 teachers of grades 7 to 12 in the German-
384 speaking part of Switzerland. It provided an initial assessment of expectations and requirements regarding information
385 materials on current earthquake topics, proposed exploratory activities and experiments, interest in RS seismometers and
386 preferences for different teaching formats. The survey was created using Unipark (https://www.tivian.com, last accessed
387 December, 2025) and distributed via personal contacts and comprehensive email lists available at ETH Zurich. Participation

388 was anonymous, and responses could not be traced back to individuals. Teachers could voluntarily provide contact details, if

389 they were interested in receiving a seismometer, but these details were not linked to their answers.

390

391 A second online survey was conducted between August and September 2025 among participating teachers. Its aim was to

392 assess the initiative's effectiveness, i.e. to gain a comprehensive understanding of how schools evaluated the activities and the

393 provided teaching materials, in line with the overarching research interest. The questionnaire (see **Supplements**) comprised

394 23 questions covering four areas: overall impression and reach, use of Raspberry Shake seismometer, the *Lambda Slinky*

395 *Seismometer* and the developed teaching materials. The survey was created using Microsoft Forms (https://forms.office.com;

396 last accessed 28 November 2025) and distributed by email to all participants on 12 August 2025. Teachers had one month to

397 respond. The questionnaire was available in both German and French and sent to approximately 44 recipients across

398 participating schools. In total, 18 teachers responded, representing a response rate of 40.9%; two-thirds (67%) were German-

399 speaking and one-third (33%) French-speaking. The survey was anonymous, with an option for participants to voluntarily

400 disclose personal information at the end. All respondents were informed that the survey data would be use for the project's

401 final report and for scientific research purposes.

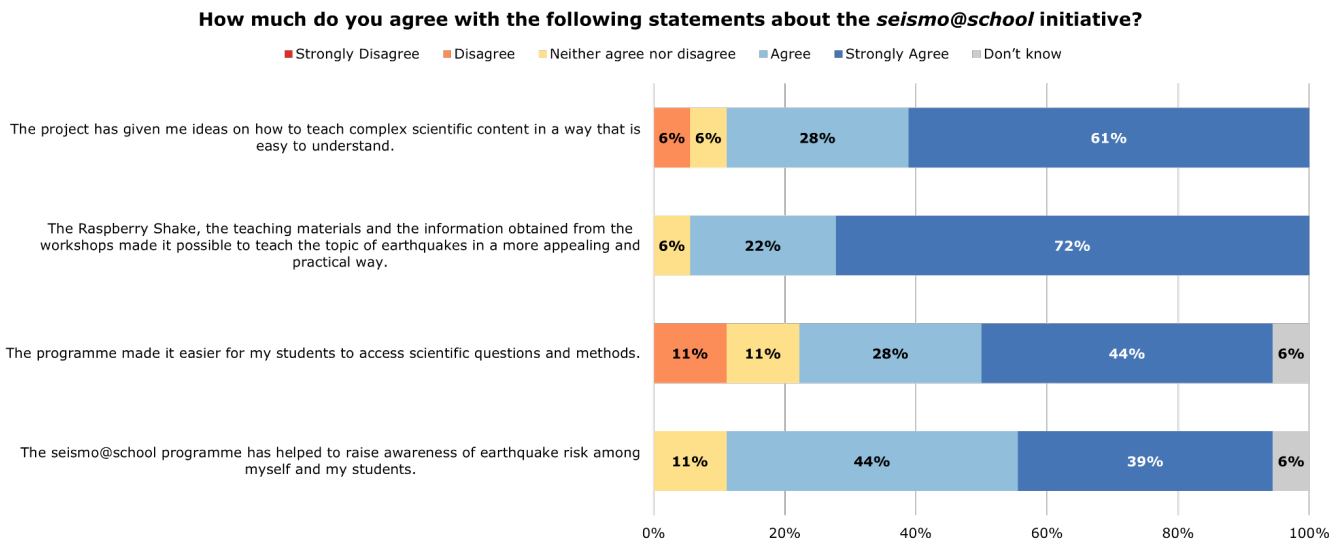## 4 Evaluation of Activities

403 The following sections present the results of the second online survey, which provides the basis for the evaluation of activities.

4.1 General Impression

405 Most respondents (78%) rated their participation in the *seismo@school* initiative very positively, while 22% gave a neutral

406 response. A large majority indicated that the initiative inspired their classroom teaching (89%) and helped raise awareness of

407 earthquake risk among both students and teachers (83%). Overall, participants expressed a high level of satisfaction with the

408 programme and considered it a valuable link between academic research and secondary education, promoting scientific

409 thinking and strengthening awareness of earthquake risk in school (**Figure 5**).

410 Teachers' qualitative feedback emphasised the educational benefits of transdisciplinary collaboration between schools and

411 scientific experts, particularly in terms of bridging the gap between scientific depth and practical classroom application. The

412 teachers particularly valued the workshops and the regular email updates about recent earthquake detections or other

413 phenomena recorded by the network.

How much do you agree with the following statements about the *seismo@school* initiative?

414

Figure 5: Results of the online survey (question 1) on various statements about the general impression of the *seismo@school Switzerland initiative*. Participants (n = 18) rated their agreement with four statements on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. Percentages indicate the distribution of responses for each statement.

4.2 Use of Raspberry Shake Seismometers in School Lessons

Survey participants reported having already used the Raspberry Shake with more than 955 students. Thirteen teachers (72%) agreed that the Raspberry Shake helps explain earthquakes more clearly, and two-thirds (66%) consider the seismometer well suited for classroom use. Although a smaller group of teachers (38%) reported using the device to analyse local or global earthquakes (**Figure 6**), several mentioned using the recordings of the Blatten landslide in May 2025 with their classes or incorporating them into activities such as jumping tests or other recorded vibrations (e.g., trucks, train traffic, or machinery). Some teachers also highlighted a couple of practical challenges and a need for additional guidance and technical support, particularly regarding data management and network connectivity.

Please rate the following statements about the use of your *Raspberry Shake* seismometer

■ Strongly Disagree ■ Disagree ■ Neither agree nor disagree ■ Agree ■ Strongly Agree ■ Don't know

Figure 6: Results of an online survey on various statements regarding the use of Raspberry Shake seismometers in classrooms (question 8). Participants (n = 18) rated their agreement with four statements on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. Percentages indicate the distribution of responses for each statement.

4.3 Teaching Materials and Seismometer Kit

The teaching modules were published online between spring and summer 2025. Two-thirds of survey participants (66%) had already viewed at least one module, but–given the short time before the survey and the start of the new school year–only about one-third (33%) had used them in class. Among those who viewed at least one module, more than 80% rated them as good or very good. Respondents valued the clarity of explanations, well-designed graphics, and the integration of realistic and locally relevant examples. Teachers found the materials adaptable and pedagogically sound, although some reported time constraints limiting full integration into their curricula.

By August 2025, we had distributed 21 *Lambda Slinky Seismometer*s to schools across Switzerland (see **Chapter 2.3**). As additional kits remain available, we will continue to provide them to interested Swiss schools. Of the 18 survey respondents, 11 reported owning such a device, and just over half of them (54%) found it exciting to use them in their lessons. According to the comments, most teachers had not yet had the opportunity to use the device in class due to the summer holidays. A more detailed evaluation will therefore be possible at a later stage.

5 Discussions

The *seismo@school Switzerland* initiative demonstrates how experiential, data-driven learning can translate complex seismological concepts into meaningful classroom experiences. By combining real-time data with locally relevant examples, students engage in observation, experimentation, and interpretation, thereby strengthening both conceptual understanding and

446   scientific literacy. Although the initiative requires significant effort from scientists to support its implementation, its success

447   depends primarily on effective knowledge transfer–through appropriate language and communication formats–rather than on

448   overcoming scientific challenges. Teachers emphasized that collaboration with scientific experts effectively bridged the gap

449   between research and school practice. This transdisciplinary approach aligns with the student-centred format advocated by

450   Subedi et al. (2025), who emphasize that immersive, locally contextualized education can foster preparedness and strengthen

451   the link between science and society. *Seismo@school* also aims to strengthen STEM education more broadly and may help

452   counter the global trend of declining student interest in Earth sciences (e.g., Martinez, 2022) and related disciplines as future

453   career paths.

454   While these findings highlight the project's potential to enhance science education, certain methodological limitations should

455   be acknowledged. The survey conducted as part of the project provides an initial indication of its potential impact. Although

456   the response rate of 40.9% is acceptable, the overall sample size remains limited, which restricts the generalisability of the

457   findings. In addition, the survey period was relatively short, and many teachers will only implement the modules in the coming

458   months. Repeating the survey at a later stage would therefore be advisable. Furthermore, it would be valuable to assess the

459   direct impact on students (e.g., Subedi et al., 2025).

460   The integration of earthquake education in Swiss schools is shaped by *Lehrplan 21 ("Study Plan 21")*, a joint curriculum

461   framework developed during 2010-2014 and adopted by 21 German-speaking or multi-language cantons and the Principality

462   of Liechtenstein for primary and lower secondary levels. Although *Lehrplan 21* promotes interdisciplinary, competence-

463   oriented teaching across geography, natural sciences, and technology, earthquakes receive only limited explicit coverage. The

464   situation is the same in the French-speaking part of the country and the *Plan d'Etudes Romand.* Implementation thus depends

465   largely on cantonal priorities and individual teacher engagement. Survey responses indicated that most teachers devote only a

466   few hours per semester to the topic, reflecting the limited curricular emphasis. The *seismo@school* resources and activities

467   developed during our programme partly compensate for this gap by offering ready-to-use materials aligned with *Lehrplan 21*,

468   which may enhance teachers' confidence and motivation to address the subject within existing time constraints. Expanding the

469   number of instructional hours dedicated to earthquakes or natural hazards in official study plans would, however, require

470   educational–political efforts involving multi-year negotiations, beyond the scope of short-term (two-year) projects.

471   The introduction of Raspberry Shake and *Lambda Slinky Seismometer*s creates tangible connections between theory and

472   observation, allowing students to collect and analyse real seismic data and (possibly unconsciously) benefit from the *IKEA*

473   *effect*. This practical engagement promotes curiosity and reveals the potential of open data for inquiry-based science education.

474   However, technical challenges–in particular regarding strict firewall settings in schools–highlight the need for ongoing

475   guidance and institutional support including IT experts. Sustained collaboration with schools will be essential to ensure

476   continuity and maintain data quality in classroom applications.

477 Beyond formal education, the initiative strengthens the interface between science and the public. Museum exhibitions, public
478 events, and multilingual online resources expand access to seismological knowledge and foster dialogue about earthquake risk.
479 By connecting classroom-based sensors to the national seismic network, *seismo@school* makes scientific data more accessible
480 and transparent, thereby reinforcing public trust in research institutions. This participatory element aligns with broader citizen-
481 science initiatives that link community engagement to shared awareness and resilience. The initiative aims for students to act
482 as intermediaries of knowledge, fostering awareness of earthquake science and preparedness beyond the classroom and into
483 their homes and neighbourhoods. This aspect can become an invaluable addition in countries located in high to very high
484 seismic hazard levels. A clear challenge remains the mid- to long-term funding of such efforts. The most promising avenue
485 for sustainability may lie in the development of appropriate policies on earthquake education (e.g., Hetényi & Subedi, 2023).

486 Although the *seismo@school* network was created primarily for educational purposes, the Raspberry Shake seismometers have
487 become a valuable complement to Switzerland's professional seismic monitoring system. They help reduce spatial data gaps
488 in the seismic network and enhance the characterization of local earthquakes. Moreover, integrating the Raspberry Shake
489 sensors into the professional seismic monitoring network of the Swiss Seismological Service ensures regular quality checks,
490 technical support, and long-term maintenance. In this way, both the schools and the professional network benefit. Overall,
491 *seismo@school Switzerland* illustrates how a locally embedded, student-centred initiative can simultaneously advance seismic
492 monitoring, scientific research, strengthen earthquake education, and enhance societal preparedness by raising awareness of
493 seismic risk among young people and their families.

6 Conclusions and Outlook

495 The revival and expansion of *seismo@school Switzerland* demonstrate the value of combining formal education, citizen
496 science, and professional monitoring in a single framework. Even in regions of moderate seismic hazard–but considerable
497 risk–, sustained educational efforts are essential to maintain awareness of earthquake risk and to prepare society for rare but
498 potentially damaging events, as well as for events people may face during travels to high-risk zones. The integration of real-
499 time instruments, modular teaching resources, and international collaboration positions Switzerland as an active partner in the
500 global educational seismology community.

501 This project has laid the groundwork for a sustainable, nationwide *seismo@school* initiative. In the near to mid-term, the
502 programme aims to continue supporting teachers and public engagement, expand the sensor network and learning materials–
503 particularly to include lower secondary schools–and deepen partnerships with international school programmes while
504 promoting Swiss-developed teaching materials abroad, for example in Nepal. Further efforts will focus on developing citizen
505 science components, strengthening integration with cantonal Education Departments, and broadening the teacher network to
506 include subjects such as physics, computer science, and mathematics. In parallel, collaboration within and among the Swiss
507 academic institutions involved in the project will be reinforced, and links to other earthquake-related natural hazards, including

508   volcanoes and tsunamis, will be explored. The *seismo@school* network now forms a strong foundation for long-term

509   collaboration between schools and Earth scientists in Switzerland. Participating in such a project as a scientist is both

510   meaningful and rewarding: it enables the achievement of multiple milestones and often elicits enthusiastic feedback - beyond

511   the inherent satisfaction of contributing to a societally relevant and useful initiative.

Data availability

513   Educational materials (available in English, German, French, and Italian) developed through this project can be accessed at

514   http://seismo.ethz.ch/en/news-and-services/for-schools/teaching-resources/ (last accessed November 2025). Seismic

515   waveform data from the Raspberry Shake school network Switzerland (http://seismo.ethz.ch/en/news-and-services/for-

516   schools/raspberryshake-school-seismometer/, last accessed November 2025) can be downloaded from the European Integrated

517   Data Archive (EIDA). The FDSN network code for the project is "S" (https://networks.seismo.ethz.ch/en/networks/s/).

518   Seismologists can access the data using standard FDSN services operated by the SED: for example metadata at

519   https://eida.ethz.ch/fdsnws/station/1/query?network=S&format=text&level=sta&nodata=404 and waveform data can be

520   accessed from the dataselect service, e.g. https://eida.ethz.ch/fdsnws/dataselect/1/ (last accessed November 2025). Citation

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523   school sensors (network code *S*) in Switzerland are available at https://networks.seismo.ethz.ch/en/networks/s/psd/ (last

524   accessed November 2025).

Supplement

526   Supplementary material includes the school evaluation questionnaire (see **Chapter 3**).

Author contributions

528   Conceptualization: MB, NV, GH, RRo, ID; Installation and operation of RS school network: MB, GH, NV, RRa, RRo, JC,

529   UF, SS; Development and editing of teaching resources: NV (lead), ID, MB, GH, RRo, FH, MM, TJ, AS, KB; Development

530   of exploratory activities: RRo; Development, conduct, and analysis of survey: NV; Writing - original draft preparation: MB,

531   NV; Writing - review and editing: GH, RRo, ID, KB, JC, FH, MM, RRa, AS, SS, WS.

Competing interests

533   The authors declare that they have no conflict of interest.

Ethical Statement

This study did not involve human-subject research or the collection of personal data, since the survey could be conducted anonymous. However, participants were able to voluntarily enter their details at the end of the survey. These were not required for the evaluation at any time, nor were they passed on to third parties. Surveys were only conducted with individuals who were involved in or interested in the project. Due to these reasons, this study did not require formal ethical approval under Swiss guideline.

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