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Improving earthquake resilience in the Taupō Volcanic Zone (TVZ) using school-based seismometers and connected education programmes

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ABSTRACT

Over the past decade "seismometers in schools" programmes have been developed in Aotearoa New Zealand and overseas, by a range of organisations, for a variety of reasons and aiming to achieve a range of educational outcomes. With the enhancement of digital seismic networks, the decreasing cost of sensors, cheaper and faster internet, and the increasing interest in "citizen science" a range of opportunities exist to further expand participation of schools and other institutions in this space. This paper explores the recent development of a "seismometers in schools" programmes in the Taupō Volcanic Zone (TVZ), as part of the ECLIPSE

Programme(Eruption or Catastrophe: Learning to Implement Preparedness for future Supervolcano Eruptions) and discusses the opportunities and challenges for such programmes.

1 INTRODUCTION

Over the past decade several "seismometers in schools" programmes have been developed in Aotearoa New Zealand (e.g. the Rū network - https://ru.auckland.ac.nz/) and overseas (Tataru et al. 2016; Balfour et al. 2014; Cochran 2009). These have been coordinated by a range of organisations, for a variety of reasons and aiming to achieve a range of outcomes. With the enhancement of digital seismic networks, the decreasing cost of sensors, cheaper and faster internet, and the increasing interest in "citizen science" a range of opportunities exist to further expand participation of schools and other institutions in this space.

1.1 ECLIPSE – Improving earthquake and volcano resilience in the Taupō volcanic zone

The MBIE-funded ECLIPSE Programme (Eruption or Catastrophe: Learning to Implement Preparedness for future Supervolcano Eruptions) is a multidisciplinary research project which aims to reduce the uncertainty around future volcanic eruptions or unrest from caldera volcanoes in New Zealand. Lake Taupō (see Figure 1) in the Taupō Volcanic Zone, is one such caldera with a unique seismic and geothermal landscape. A key component of the Programme is to improve the communication of volcano science to communities potentially affected by volcanic hazards.

The objectives of this component of the Programme are to involve and educate school and wider community members about the Taupō Volcanic Zone and its hazard, as well as improving science understanding, through:

- Exploring and developing co-production methods with iwi for citizen science, education and graphical communication.
- Paralleling the synergy of mātauranga Māori and science.
- Including school students in the collection and interpretation of seismic data from the Taupō Volcanic Zone, conducting citizen science, and building interest in and understanding of earthquakes and seismic engineering and safety.
- Preparing Iwi co-produced graphical communication and education resources related to understanding the TVZ and risks from it, for students and the general public.

To this end Raspberry Shake seismometers (Figure 2) will be used as a tool for engaging the community in this new research, and Earth sciences more broadly. This will build upon outreach endeavours which have already taken place through the installation of a research-quality seismic network around Lake Taupō (Illsley-Kemp et al., 2020). Both mainstream and Māori-medium schools of different age-ranges have been identified throughout the central North Island, from Taupō to the Bay of Plenty. An additional aim of this work is to utilise different community centres (e.g. museums, marae, libraries) to connect with adult community members. The primary objectives are:

- To provide teachers with new and engaging classroom activities that can be built into the current science curriculum to increase student interest in Earth sciences.
- To disseminate volcano-research to the community in an accessible manner.
- To foster stronger connections between research institutes/universities and the community, supporting science literacy and trust.

As with the ECLIPSE project, our Raspberry Shake project will be undertaken using a co-production approach to deliver education and outreach content that is culturally appropriate and accessible to different communities. The roll-out of the first ten seismometers is planned for early to mid-2021.

Figure 1: This aerial view shows Lake Taupō amid the whenua (land) of Ngāti Tūwharetoa on the North Island of New Zealand. This lake fills the caldera of a volcano that continues to alter the surrounding seismic and geothermal landscape. A new seismic network is providing a more detailed picture of the magmatic system and seismic activity in this culturally and economically important region. The Raspberry Shake seismometers will supplement the research seismometers. Credit: Dougal Townsend/GNS Science

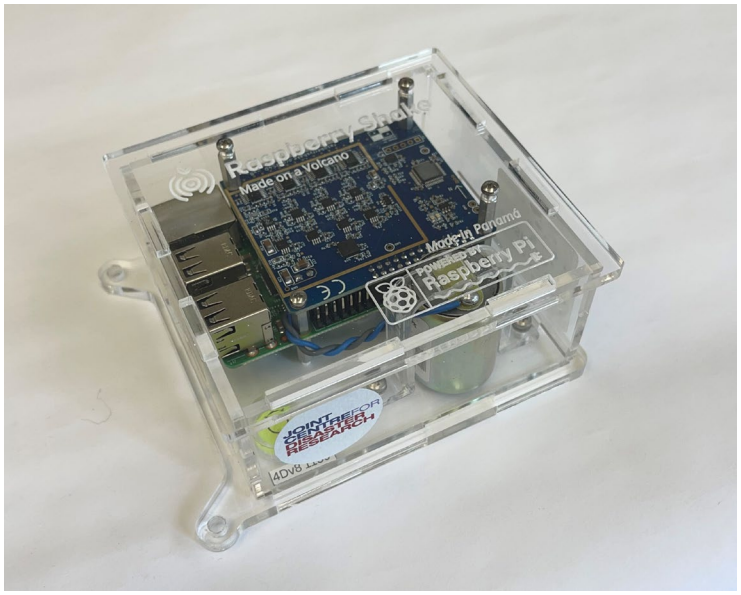

Figure 2: A Raspberry Shake seismograph in a standard clear acrylic case. The brass cylinder frame contains the geophone. The green board in the case is the Raspberry Pi computer, and the Raspberry Shake header board sits atop it. Credit: Lucy Kaiser

2 OPPORTUNITIES AND CHALLENGES OF THE PROGRAMME

The opportunities of these "seismometers in schools" programmes have been addressed by several authors in the literature (e.g. Balfour et al., 2014, Salmon et al., 2015, Subedi et al., 2020) and include: 1) raising awareness of earthquake hazards; 2) raising awareness of subjects like seismology, geoscience and other Science, Technology, Engineering and Mathematics (STEM) areas as a field of study; 3) promoting science as a possible career or area of tertiary study: and 4) a tool to assist educators in their teaching of physics, maths, geology, geography and computer sciences. Additional opportunities and benefits include: 1) linking school-based learning to household awareness and education around earthquake resilience (Finnis et al. 2008); 2) connecting to wider community-based emergency management and disaster risk reduction activities (Feng et al. 2018), and 3) contributing data for earthquake detection research (Subedi et al. 2020); 4) developing appropriate te reo Māori/matauranga Māori/Western science braided education resources for the rohe of Wharekauri, Te Arawa and Mataatua waka.

'Seismometers in schools' programmes can enhance interconnectedness of schools. The sensors can link to virtual seismological networks which create a sense of cooperation between schools (Balfour et al., 2014). For example, an educational seismology project in Nepal was able to create a Seismology Network from the cooperation of an educational network of 22 schools (Subedi et al. 2020). Such programmes facilitate collaborations between scientists/researchers and school teachers, thus potentially creating stronger linkages between primary, secondary, and tertiary education. A highlight from the Nepal project involved creating an intensity map that uses data gathered from schools, demonstrating the collaboration with the community of schools and researchers (Subedi et al. 2020).

Like all education initiatives "seismometers in schools" are not without challenges. For programmes to scale-up or to extend for longer periods depend on numerous factors. Existing research has identified key factors that may contribute to successful programmes of this nature. For example, various case studies have seen value in teacher and student engagement (Bravo et al., 2020), usable and reliable low-cost sensors (Subedi et al., 2020), as well as steady funding sources (Khan et al., 2018). Successful programmes that pass the test of time often received top-down support from national, regional, or international agencies; see Taiwanese example (Chen et al., 2015). Moreover, bottom-up or citizen/community-driven programmes – such as the those in Australia (Salmon et al., 2015) and Nepal (Subedi et al., 2020) – rely heavily on continued enthusiasm and interest of researchers, teachers, and communities involved.

The sustainability of programmes can be affected by loss of funding, lack of universal "buy-in" from staff, school curricula fullness resulting in resistance for additional activities and staff turnover (Finnis et al. 2008; Khan et al. 2018). Many programmes have also not been fully evaluated (Johnson et al. 2014). Although there are multiple benefits and opportunities in "seismometers in schools" programmes, there is greater need to investigate the operational challenges and evaluation aspects of sustainably running such programmes.

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REFERENCES

Balfour, N. J., Salmon, M., & Sambridge, M. (2014). The Australian seismometers in schools network: Education, outreach, research, and monitoring. *Seismological Research Letters*, 85(5), 1063-1068. doi:10.1785/0220140025

Bravo, T., Taber, J., & Davis, H. (2020). A Case Study of Highly-Engaged Educators' Integration of Real-Time Seismic Data in Secondary Classrooms. *Frontiers in Earth Science*, 8(June), 1–10. doi: 10.3389/feart.2020.00180

Chen, D. Y., Wu, Y. M., & Chin, T. L. (2015). Incorporating low-cost seismometers into the Central Weather Bureau seismic network for Earthquake Early Warning in Taiwan. *Terrestrial, Atmospheric and Oceanic Sciences*, *26*(5), 503–513. doi:10.3319/TAO.2015.04.17.01(T)

Cochran, E.S., J.F. Lawrence, C. Christensen, and R. Jakka, (2009). The Quake-Catcher Network: Citizen science expanding seismic horizons. *Seismological Research Letters*, 80, 26-30.

Courboulex, F., Berenguer, J. L., Tocheport, A., Bouin, M. P., Calais, E., Esnault, Y., ... & Virieux, J. (2012). Sismos à l'Ecole: A worldwide network of real-time seismometers in schools. *Seismological Research Letters*, 83(5), 870-873.

Feng, S., Hossain, L., & Paton, D. (2018). Harnessing informal education for community resilience. *Disaster Prevention and Management*, 27(1), 43-59. doi:10.1108/DPM-07-2017-0157.

Finnis, K., Johnston, D., Becker, J., Ronan, K. R., & Paton, D. (2007). School and community-based hazards education and links to disaster-resilient communities. *Regional Development Dialogue*, 28(2), 99-108.

Khan, A., Denton, P., Stevenson, J., Bossu R. Engaging citizen seismologists worldwide. *Astronomy & Geophysics*, Volume 59, Issue 4, August 2018, Pages 4.15–4.18, doi:10.1093/astrogeo/aty190

Illsley-Kemp, F., Barker, S. J., Smith, B., & Wilson, C. J. N. (2020). Implications of a supervolcano's seismicity. *Eos*, 101(6), 28–32.

Johnson, V. A., Ronan, K. R., Johnston, D. M., & Peace, R. (2014). Evaluations of disaster education programs for children: A methodological review. *International Journal of Disaster Risk Reduction*, 9, 107-123. doi:10.1016/j.ijdrr.2014.04.001.

Johnson, V. A., Ronan, K. R., Johnston, D. M., & Peace, R. (2016). Improving the impact and implementation of disaster education: Programs for children through theory-based evaluation. *Risk Analysis*, 36(11), 2120-2135. doi:10.1111/risa.12545.

Salmon, M., Balfour, N., & Sambridge, M. (2015). Australian Seismometers in Schools. *Proceedings of the Tenth Pacific Conference on Earthquake Engineering*, 133.

Subedi, S., Hetényi, G., Denton, P., & Sauron, A. (2020). Seismology at School in Nepal: A Program for Educational and Citizen Seismology Through a Low-Cost Seismic Network. *Frontiers in Earth Science*, *8*(April). doi:10.3389/feart.2020.00073

Tataru, D., Zaharia, B., Grecu, B., Tibu, S., Brisan, N., & Georgescu, E. S. (2016). Seismology in Romanian Schools: education, outreach, monitoring and research. *Romanian reports in physics*, 68(4), 1589-1602.