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The challenges of technological tools and electronic classrooms in regional Australian schools: perspectives from STEM teachers

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ABSTRACT: Many students in Australian regional communities and schools do not have electronic devices and cannot access technological tools outside their school environment due to financial difficulties and family-related factors. Guided by the Technological Pedagogical Content Knowledge framework, this study addressed the following question: based on the National STEM School Education Strategy 2016-2026, how do secondary school teachers describe their application of, and experiences with, technology to teach STEM to students with little or no access to technology outside their classroom environment in regional Australia? The results indicate that technological knowledge with additional physical activities, and pedagogical content knowledge with modelling, laboratory and outdoor activities are some of the keys to solve the technological challenges in regional communities and schools. The study may inform government leaders, school leaders and teachers about the need to review their current financial resources management, contributions and regional development plans to successfully address the technology-based challenges in remote Australian areas.

INTRODUCTION

The application of technology in education, teaching and learning has increased over the last decade. In regard to personal use of technology, individuals usually have a computer, cellular phone, Bluetooth and Wi-Fi, to connect with other people on-line. In many traditional and on-campus classroom environments, computers, projectors, Internet access, and visual and audio technology have long been introduced to enhance learning and increase student engagement. Also, students may submit their assignments, participate in examinations or apply for university admission on-line instead of on paper [1].

Around 7 million people (28%) of the Australian population live in regional areas. Although the governments invest resources and facilities in those areas, many regional populations continue to face challenges arising from the geographic location and unequal access to technology. Students in regional schools and communities might not receive the same level or quality of educational material due to a poorer technological development in the regions. Not until recently, i.e. 2020/2021, the New South Wales government decided to invest AUD$366 million for over 1,000 regional schools within the Rural Access Gap (RAG) package [2].

According to the Australian National STEM School Education Strategy 2016-2026, Australian students should receive proper science, technology, engineering and mathematics (STEM) education regardless of their geographic location and family background. Based on the National STEM School Education Resources Toolkit, it is expected that teachers, schools leaders and industries will establish more partnerships to upgrade the STEM and technologically-assisted education in the classroom environment [3].

Over the past decades, the technology-based curriculum has been developed in many secondary schools in Australia. The federal government has also supported numerus upgrades in public schools regardless of their location and the residents' socio-economic background. In most urban schools, teachers and students have access to computers, tablets and cellular phones during their on-campus activities. Increasingly, teachers and students may communicate from on-line learning platforms and forums, and to access learning materials and assignments. However, technology is expensive, and hence challenging to regional and remote schools that have limited resources, few skilled technicians, unstable student enrolments and teachers' shortages [4].

Purpose of the Study

Unlike other liberal arts subjects, such as English, history or religious studies, STEM subjects rely highly on the applications of technology, laboratory experiments and updated information from mostly on-line sources. This study aimed to investigate the experiences of secondary school teachers in applying technology to teach STEM to students in regional Australian areas with financial difficulties, and particularly to students with little or no access to technology outside their classroom environments. The results of this study may help school principals, school department heads, local government agencies, federal government departments and researchers to understand and successfully address the lack of appropriate technology, applications and devices for students and their families in regional Australian communities. In short, the study was guided by the following research question:

Based on the National STEM School Education Strategy 2016-2026, how do secondary school teachers describe their application of, and experiences with, technology to teach STEM to students with little or no access to technology outside their classroom environment in regional Australia?

The Technological Pedagogical Content Knowledge (TPACK) Framework

The technological pedagogical content knowledge (TPACK) framework indicates that technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) have to interconnect and impact on each other, and that teachers need all that knowledge to successfully incorporate technology into school activities [5]. Moreover, content (i.e. materials in the classroom) and pedagogy (i.e. teaching and learning strategies) could be treated as tools in educational technology applications.

The understanding of tools, such as computers, applications, teaching strategies, is essential for successful educational outcomes as different subjects may require different methodological approaches, and individual students may have different learning preferences. Therefore, the abovementioned TK, PK and CK cannot function in isolation from each other, but have to form connections. As a result of these connections, the following domains can be identified: technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), and technological content knowledge (TCK). The TPK refers to the connections between technological means, such as computers and applications, and pedagogical and teaching strategies. The PCK refers to the connections between pedagogical strategies and content knowledge. The TCK refers to the connections between technological means and educational outcomes in specific content areas [5].

METHODOLOGY

The qualitative research methodology with the application of a general inductive approach has been employed [6]. The main goal of this study was to understand how secondary school teachers describe their application of, and experiences with, technology to teach STEM to students with little or no access to technology outside their classroom environment in regional Australia. In order to seek an in-depth understanding of the teachers' experiences, qualitative design is appropriate.

Recruitments and Participants Population

The purposive sampling strategy [7] has been employed to recruit 20 participants from five secondary schools in regional Australia, including Western Australia, South Australia, Tasmania, Queensland and New South Wales. First of all, the researcher contacted the STEM department heads to establish co-operation. The researcher sent the study rationale, interview protocol, focus group protocol, agreement and other relevant materials to the department heads. They agreed for the co-operation and forwarded the materials to STEM teachers in their schools for further discussions. A total of 20 STEM teachers agreed to participate in the study. The participants were expected to:

- Currently work as teachers in a regional secondary school in Australia;
- Have been involved in teaching activities in regional schools for at least five years;
- Work as STEM subject teachers.
- Currently teach students who have little or no access to technology outside their classroom environment.

Data Collection

Data collection for the study started as soon as the participants signed the agreement and sent it back to the researcher. Because of the remote locations, the researcher could only collect the data though on-line tools, and more specifically using the WhatsApp interview tool. First of all, an individual on-line interview session was arranged with each participant. Each session lasted from 65 to 98 minutes. After all participants completed their interview session, four participants joined a focus group for further discussion. Five focus group activities were held and lasted from 98 to 112 minutes. After completing the interviews and focus group activities, the voiced messages were transcribed based on each participant's input. Then, the relevant materials were sent to each participant for verification and validation. All agreed that the transcripts were true and correct records of the sessions. It is worth noting that the researcher used a digital recorder for all sessions, and that all participants agreed with the arrangement.

Data Analysis

The transcripts and other materials were re-checked and sorted to identify potential trends and groupings. The open-coding technique was used to group themes and subthemes. At the first level, 11 themes and subthemes were created. Then, the axial-coding technique was applied for further development. As a result, two themes and three subthemes were merged.

Human Subjects Protection

Privacy is the most important element in this study. The signed agreements, information about participants, contact information, employment, voiced and written messages, the researcher's computer and other related materials were locked in a cabinet. Only the researcher had the right to read the materials. After completing the study, the materials were immediately deleted and destroyed to protect the personal information of all parties involved in this study.

RESULTS AND DISCUSSIONS

The materials from 20 one-on-one interview sessions and five focus group activities were subsequently merged. Although many teachers work in different parts of regional Australia, many shared similar stories and experiences. The focus group activities allowed for further grouping of ideas. The following section outlines the identified themes and subthemes (Table 1).

Table 1: Themes and subthemes.

Technological knowledge (TK): limitation of electronic devices	
	Students show a great interest in physical activities and peer-to-peer connections
Pedagogical content knowledge (PCK): learning from the traditional classroom environments	
	Modelling from teachers: balance the use of technological tools in the classroom
	Laboratory experiments and outdoor activities as learning tools

Technological Knowledge (TK): Limitation of Electronic Devices

Although electronic devices, such as cell phones, computers and tablets, are widely used by many Australians in their daily lives, many traditional-age students in regional Australian areas do not have access to those devices. Due to government investments, many regional schools employed electronic devices in their classroom environments. However, many students do not use these items after school, particularly students from socially disadvantaged and indigenous families. As a result, many experienced the use of technological tools in the classroom environments, but not outside class. A participant commented on their experience about students from poor families:

> *…many students from poor families …cannot afford the tablet and new computer at home …their parents only use the computer at work …no computers and else at home …it is hard to force them to buy one …it is not compulsory for our curriculum…* (Participant #1, Focus Group, Biology).

Some interesting stories about students from indigenous families were also captured. For example, some of those students and their families do not believe in electronic devices and technology. Although technological tools are widely used in Australia, some families try their best to avoid these items. As the following comments illustrate:

> *…several of my indigenous students only have a landline telephone, television, and radio for messages …they love physical materials, such as books, paper examinations and paper report cards …nothing wrong because we all learnt our knowledge and examinations from books…* (Participant #4, Interview, Physics).

> *…my student's family is operating a farm …they are very simple …it is good to have technology …but I think it is the decision of each family …I agree it is good for my students to learn the agricultural skills …computer and technology …could be optional …I respect the decision…* (Participant #2, Interview, Biology).

Students show a Great Interest in Physical Activities and Peer-to-Peer Connections

Participants indicated that students in the regional areas tend to spend more time in physical activities and peer-to-peer interactions with teachers, classmates, peers and parents. To the question about their students' average time of using electronic devices based on their observation, many teachers responded that less than 30%. Many participants indicated playgrounds, afterschool academic clubs and activities, school common chat rooms, and gymnasium rooms as some of the most popular spaces for leisure activity in their school environments. More importantly, less than 60% of their students have social media accounts and on-line profiles. One comment was captured:

> *…students in the regional areas are very different …they love the nature and real-experiences with people …the engagements between people …seem very important to them …we used computer, projector, and PowerPoint in class …but only in class …students do not expect electronic devices after their classes …teachers should not expect these ideas too much …they are not the same as their urban counterparts…* (Participant #11, Interview, Mathematics).

In short, based on the TPACK framework [5], participants indicated that the students understood how to use technological tools for classroom learning and laboratory experiments based on their personal and previous classroom experiences. However, they had no strong desire for using electronic devices after school due to their personal decisions and family backgrounds [8]. Although the desire for technology is low, it does not mean the technological knowledge (TK) of those students is lower than their urban counterparts. More importantly, some students and their families believe in the traditional ways of learning, such as face-to-face learning and hands-on experiences from their teachers and mentors.

Pedagogical Content Knowledge (PCK): Learning from the Traditional Classroom Environments

All 20 participants advocated for the need to balance the use of electronic devices and technologically-assisted pedagogy with the content knowledge provided to these student groups. Although many students decided not to use electronic devices after school, it is important to note that technology and electronic devices are widely used in urban communities in Australia. Schools and teachers should provide the means and knowledge to students to facilitate their university admission or post-secondary school careers. A comment was captured:

> *…we do not need videos and computers for chemistry experiences and laboratories …we have our laboratories at school …but what about students who need to apply for TAFE and university? Paper-based applications are okay …but it is encouraged for them to submit on-line …when they move to city …they cannot be too outdated …they need to submit assignments with Microsoft Office and on-line platforms …they need to be prepared…* (Participant #8, Focus Group, Chemistry).

Modelling from Teachers: Balance the Use of Technological Tools in the Classroom

Teachers and other school staff are some of key role models and mentors for students when they acquire knowledge and skills outside their home. Many participants completed their teacher training and degree programmes in large urban areas. In other words, the participants understood why and how to employ technological tools during their classes. Two comments were captured:

> *…we are living in the middle of nowhere …but when we need to learn the diversity of global biology, animals, plants, and geographic knowledge …from other continents …we have to combine the textbook exercises and some videos …in the curriculum …it is hard to think European climates or snow without videos …both students and I did not see snow before …we all learnt that from videos…* (Participant #3, Interview, Biology).

> *…it is very hard to calculate and show the mathematical formula with a paper …I have to prepare the PowerPoint with video …to show them the progression and calculation …it is hard to draw it in a 45-minute lesson all the time …also, my students need to calculate the formula on their own …they need to have the electronic calculator …otherwise, it is useless…* (Participant #12, Interview, Mathematics).

According to a recent study by Restrepo-Calle et al, appropriate interactive tools may increase learners' performance, learning outcomes and motivation [9]. Teachers should encourage the use of these tools, even if the students refuse and reject this idea. Mafunda and Swart also indicated that e-learning applications might enrich students' experiences in regional and lower socio-financial school environments [10]. As the role models and advocates for technology, teachers should employ appropriate strategies for students who have little or no access to electronic devices outside their classroom environments. The encouragement to use technological tools will increase the understanding of them and other digital tools, and be particularly beneficial for students who wish to continue their education in university after secondary school.

Laboratory Experiments and Outdoor Activities as Learning Tools

All participants also indicated that both the natural and man-made environments and facilities are valuable for students' learning experiences. Due to government investments, secondary schools in Australia are equipped with laboratories, libraries and computer rooms. Teachers are encouraged to direct their students to these facilities at least once per week to enhance their motivation and gain on-line experience in learning.

A study by Prasetya et al indicated that an interactive electronic textbook could increase the performance and learning motivation of students [11]. If teachers employ the tool properly, the outcomes and students' experience might be increased. Also, according to a study by Borucka, outdoor and observational experiences may widen students' learning interests and improve performance [12].

In the study outlined in this article, some participants incorporated videos, textbook materials, laboratory experiments and outdoor activities into their teaching, thus providing a more holistic approach for students who have little or no access to electronic devices after school. A participant commented:

> *…teachers need to balance the time of laboratory experience, computer laboratories, the face-to-face lessons with the textbook, and outdoor times …because our students love the physical experiences …we watched the architect from the video …we discussed the formula and structure from our textbook …then, we brought our students to the community and saw the real structures…* (Participant #17, Interview, Engineering).

Another participant shared an interesting experience about a field trip to a student's family farm for outdoor learning. The participant advocated that engineering learning should involve not only traditional classroom experiences, laboratory experiments, but also field trip experiences and observations from the outdoor environments. The story about the field trip to the family farm reflects the results from another study [13], and is as follows:

> *…technology as the foundation is great for students who cannot go to the real site for observation …for example, students in metropolitan cannot go to the site easily …students in the regional area cannot use technology easily …but students in the regional area can go to the site in a minute …I take this advantage and bring my students to the farm for observation …we learnt how cows live in a wooden house …the structure of the farm and else …although they do not have technology outside of my class …they have all materials in their home and in nature…* (Participant #18, Interview, Engineering).

Some findings of this study concur with the ideas from a recent study about the connection between rural community knowledge and its potential to enhance STEM education in regional Australia [14]. Although regional Australian governments do not have enough resources to facilitate the use of technological devices by all local students, the local communities can also learn from valuable, locally available resources, which are not easily accessible to urban students. Due to new and emerging developments in visual learning tools [15], students may benefit even more from their teachers' pedagogical content knowledge (PCK) [16].

Although many students have little or no access to technology outside their classroom environments in regional Australian schools and communities, teachers do not believe this disadvantage will limit the students' learning performance, experience and outcomes [8]. Due to special arrangements and balance in learning, all participants indicated that the limited technology can be offset to some extent by physical activities, which provide peer-to-peer and outdoor opportunities for learning and experiences. However, it is still important to ensure some essential skills development, such as understanding on-line platform instructions and basic computer knowledge, as after graduation regional secondary school students will have to meet the same expectations as their urban counterparts [17].

LIMITATIONS AND FUTURE DEVELOPMENTS

The current study captured the comments from 20 STEM teachers who are working in regional Australian communities. Unlike their urban counterparts, regional Australian students may have little or no access to technology outside their classroom environments. However, the current study only collected data from STEM teachers. Comments and observations from other liberal arts and vocational teachers could be different. Therefore, future research studies may add additional data from teachers of other subjects in regional schools and communities.

Post-secondary students may face similar issues due to limited access to technology. As TAFE and university students highly rely on technology-based teaching and learning tools for assignments, discussion, sharing ideas, tools and materials, and more, the voices from these groups of students are very important. Again, future research studies may also include this population.

One of the hardest parts of this study was the recruitment. Unlike schools in urban regions, regional Australian schools are affected by significant shortages of qualified and experienced STEM teachers, which was also confirmed by the findings of this study. Further investigation of these workforce problems seems essential to improve the quality of teaching and learning in regional Australian schools.

CONTRIBUTION TO THE PRACTICE

Although this study was focused on regional school communities in Australia, its finding may also contribute to three different areas.

First, although many developed countries, including Australia allocate appropriate resources and investment in the educational system, many regional, rural and remote communities and schools do not benefit from these developments. As a result, many students have little or no access to technology for learning outside the classroom environment. The current study provides yet another alert to government leaders at all levels to reassess resource distribution, so that remote schools and communities could participate in the established programmes in a more equitable way.

Second, based on the interviewees' input, it is clear that there is willingness and urgency to focus on the development of technology applications in regional Australian schools and communities. The participants indicated that many students refused to use electronic devices as they did not have such experiences at home and in their communities. Although the Australian National STEM School Education Strategy 2016-2026 provided the basis for school facility investment and development in the regions, some local communities have been left with outdated technology.

The government may consider establishing new development schemes for local communities, local business companies and local school facilities in order to upgrade the regional areas within one whole package. It appears that upgrading only the school environment cannot solve the problems of rural and remote communities and their residents. Without broader and more fundamental developments, excellent school facilities on their own cannot successfully address the challenges in rural and remote communities.

Third, the results from this study include some curricular insights and instructions from the STEM teachers. As mentioned, many students have little or no access to electronic devices outside their classroom environment. In view of this, the teachers have introduced flexible plans, outdoor activities, laboratory experiments, and field trips focused on observations, combined with the use of technological tools and methods. Importantly, the teachers take advantage of the natural learning environment as a learning tools to compensate for the inadequate access to technology after school. This particular finding may be of interest to teachers in developing countries and regions in their endeavours to successfully incorporate their local knowledge within the PACK framework.

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