Teachers and Curriculum

Journal website: http://tandc.ac.nz

ISSN 2382-0349

Published by the [Wilf Malcolm Institute of Educational Research](#)

Wilf Malcolm Institute of Educational Research
Te Pūtahi Rangahau Mātauranga o Wilf Malcolm
THE UNIVERSITY OF WAIKATO

Teachers and Curriculum, Volume 21 Issue 2, 2021.
Special Issue: *Quality STEM education*

Using emerging technology to draw learning across the curriculum

Kathryn MacCallum, Tynneale Rimmer & Kay Le Comte

Special Issue Editors: *Elizabeth Reinsfield, Chris Eames & Wendy Fox-Turnbull*

To cite this article: MacCallum, K., Rimmer, T., & Le Comte, K. (2021). Using emerging technology to draw learning across the curriculum. *Teachers and Curriculum, 21*(2), 37–44. https://doi.org/10.15663/tandc.v21i0.383

To link to this volume: https://doi.org/10.15663/tandc.v21i0

USING EMERGING TECHNOLOGY TO DRAW LEARNING ACROSS THE CURRICULUM

KATHRYN MACCALLUM,[1] TYNNEALE RIMMER[2] & KAY LE COMTE[2]
University of Canterbury[1] & Tamatea High School[2]
New Zealand

Abstract

To drive the wider adoption of STEM in schools, researchers have promoted the benefits of teaching STEM subjects integrated across the curriculum. This integration can support more authentic learning opportunities where learning is framed in real-world application or driven through problem/project-based learning. The integration of digital technologies (DT), where the learning moves away from consumption to creation, provides for further application of learning where the development of artefacts can be situated within other subjects. This integration, however, raises new challenges for effective teaching and learning, and while new technologies and approaches can support this practice, this is still evolving. In this study we explore how one high school in New Zealand has integrated the creation of digital artefacts situated, in the digital technologies (DT) class, with learning in the Māori Performing Arts class. The study explores how mixed reality (MR), combined with design thinking approaches, provide new opportunities to integrate learning and support engagement in STEM. Drawing on a participatory action research methodology, this article explores the experiences and perceptions of three teachers as they adopt MR to engage and teach students drawing on critical DT skills.

Introduction

Worldwide there is a growing recognition of the importance of attracting students towards science, technology, engineering, and mathematics (STEM) subjects in schools. In New Zealand (NZ), there has been a recent change to the Technology learning area within the NZ Curriculum. The changes were made to better support students to engage with digital technologies (DT). The changes have meant that all students will be expected to develop an understanding of Computer Science (CS) concepts from Years 0–13 (5–18 years of age) and develop skills required for development of digital artefacts (Ministry of Education, 2017).

Computational Thinking (CT), a central concept of CS, has been recognised as a critical 21st century skill, and vital for the effective understanding for digital artefact development (Guggemos, 2021). The teaching of CT helps to develop a student's ability for "solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer science" (Wing, 2006, p. 33). While CT is generally accepted as something that can be developed in CS, some aspects can be integrated across the curriculum to support authentic application of these concepts (Fluck et al., 2016). It is this integration that has the potential to transform what is taught in other subject areas to support a deeper engagement of learning where the construction of digital artefacts can drive diverse learning outcomes (Fluck, 2003). Its application provides opportunities for students to develop logic, collaboration, cooperativity, problem solving, creativity, communication, critical thinking and self-efficacy (Tikva & Tambouris, 2021).

The benefits for teaching CT, through integration across subjects, is not a unique concept. Advocates for STEM education (including DT) have increasingly advocated for the benefits of integration to support improved engagement in STEM subjects (Margot & Kettler, 2019). The approach enables learning to be more authentic and connected by drawing on interdisciplinary learning supported by real-world issues and problem-based learning (Asghar et al, 2012). Effective integration, however, requires teachers to have a wider set of skills and knowledge to drive learning (Margot & Kettler, 2019). Teachers need to be able to effectively weave together subjects, which often requires them to draw on new approaches and technologies to support this learning.

Corresponding author
Kathryn MacCallum kathryn.maccallum@canterbury.ac.nz
ISSN: 2382-0349
Pages 37–44

The adoption of emerging technology provides new opportunities for creative and innovative learning (So & Kim, 2009). The integration of technology, especially where learning is driven through creation, however, requires teachers to have sufficient technical, content and pedagogical knowledge (Fox-Turnbull, 2019). It is, therefore, important that teachers are provided with opportunities to explore and develop their teaching practice to be able to use and integrate new technology. By showcasing and exploring new ways in which subjects can be drawn together through the use of digital technology can provide teachers with a starting point to revaluate their own practice and support wider adoption (So & Kim, 2009).

The purpose of this study

This article reports on a one-year investigation exploring how teachers have used digital technologies, specifically mixed-reality (MR) tools to drive learning. It reports on a group of teachers that were engaged with a larger research project which focused on developing a better understanding of how learning can be developed through artefact development integrated across different contexts. The focus is how DT can sit alongside a Māori Performing Arts (MPA) class to support diverse learning opportunities. This teacher-driven investigation adopts a participatory design approach and research methodology to explore the experiences of these participant teachers.

The primary research question explored in the project was: How can digital technologies, specifically mixed-reality (MR) tools, be adopted to facilitate learning across the curriculum? This article presents the approaches and experiences of three participant teachers involved in this project. Drawn from a series of interviews and observations, the study explored the approaches taken by these participant teachers to integrate the application of DT in an authentic and applied approach.

2.Literature review

Mixed reality in education

MR supports the merging of real and virtual worlds to produce new environments and visualisations where physical and digital objects co-exist and interact in real-time (MacCallum & Jamieson, 2017). The MR continuum links both virtual and augmented reality, whereby virtual reality (VR) enables learners to be immersed within a completely virtual world, while augmented reality (AR) blends the real and the virtual world. The integration of MR into education provides specific affordances which make it specifically unique in supporting learning (Parsons & MacCallum, 2020). These affordances enable learning, which is collaborative and supports the development of digital literacy, but also builds important critical thinking and problem-solving skills (Bower, et. al., 2014).

The integration of MR in the classroom has generally focused on students being the consumers of these experiences (MacCallum & Parsons, 2019). However, by enabling students to be creators and designers of their own MR experience, this provides new opportunities to integrate learning across the curriculum and supports the development of CT. Supporting learning through the creation of artefacts has shown to provide greater engagement and outcomes for all students (Ananiadou & Claro, 2009). In the past the development of MR experiences has been hampered by the steep learning curve and costs associated with development; however, recent advancements in low-cost mobile and online technologies have provided for new opportunities for students to create their own MR experiences (MacCallum & Jamieson, 2017).

Approaches for cross-curriculum integration

The integration of STEM subjects enables learning that is driven through application. Supporting problem-solving and real-world learning means students are able to connect their learning between subjects (Margot & Kettler, 2019). The integration of subjects requires a fundamental shift away from teacher-led instruction towards more student led-instruction (Lesseig et al., 2016). New approaches are, however, needed to support students to develop necessary inductive and deductive reasoning, which is often required in these more applied learning situations (Margot & Kettler, 2019).

Design thinking is increasingly adopted to provide a structure for integrating problem-based learning in schools (Henriksen, 2017). The term "design thinking" refers to thinking skills or practices designers use to create new ideas and solve problems (Henriksen, et al., 2017). Its application in STEM as a process enables creative, interdisciplinary learning and has been shown to support learning within these new learning environments (Henriksen, 2017). It has shown to be especially powerful when encouraging students to consider different perspectives and approaches in how they conceptualise and solve problems (Li, et al., 2019).

Technology education

Drawing in the development of digital artefacts as an output of the design thinking process requires an even more evolving understanding of digital technologies, technology education and related Pedagogical Content Knowledge (PCK) (Fox-Turnbull, 2019). Digital Technologies, as a subject, is ever evolving, so too are the technologies and approaches which drive integration. This requires teachers to draw on a wider set of skills and knowledge, that is also evolving, to effectively support the integration of DT across subjects.

Methodology

The study adopted a participatory action research (PAR) design to examine and better understand how MR could be integrated into the high school. PAR is a qualitative research methodology and is considered a subset of action research, which is the "systematic collection and analysis of data for the purpose of taking action and making change" by generating practical knowledge (Gillis & Jackson, 2002, p. 264).

This article is derived from the findings from a larger research project. This larger project involved 14 teachers from two high schools exploring how MR could be used to support learning in a range of different subjects. This article relates the perceptions of three participant teachers from the larger group, drawn from the interviews conducted at the end of the project. It reflects the perceptions of three participant teachers, the Year 9 DT teacher (Tania), the Māori Performing Arts (MPA) teacher (Matua) and the Head of Technologies teacher (Taylor). Pseudonyms have been adopted to protect the identity of these teachers. The school that employed the teachers was a regional co-education school with a large Māori roll.

Tania had only just started to teach DT at the school, having previously only taught English. This was her second year teaching DT, and she was looking for new opportunities to draw more authentic contexts into her teaching. Matua was an experienced Preforming Arts teacher and had been the Māori kaiārahi at the school for many years. Despite his interest in DT, he was not a confident DT user and generally did not use it extensively in his classes. By working alongside Tania, he was supported in integrating the tools into his class. Due to Tania being new to DT, Taylor worked alongside Tania to help integrate and teach the necessary DT content. As Head of Technologies, Taylor provided the guidance to support the integration of these two subjects.

The approach taken to integrate MR

To combine the classes and to provide a focus for the students, a design thinking approach was adopted. Drawing on the school's theme for the term (change and identity), the students explored potential topics to base their own projects. Through a process of brainstorming (Figure 1), students in mixed groups of three to four peers, were asked to identify issues they faced at school which had meaning to them and linked to the general theme of the term. Many issues were raised by the students; however, through the processes of voting, the students decided to focus on the challenges faced by students transitioning from intermediate to high school, as this was a recent issue experienced by these students. Having identified the focus, the students then started the design process by empathising with the problem and sharing their own experiences. They also gathered wider perspectives by interviewing other students. Through this process, the students gained a better understanding of the problem and identified pain-points around the induction process. This included issues with new students finding their way around the school and gaining a deeper understanding how things work and the culture of the school.

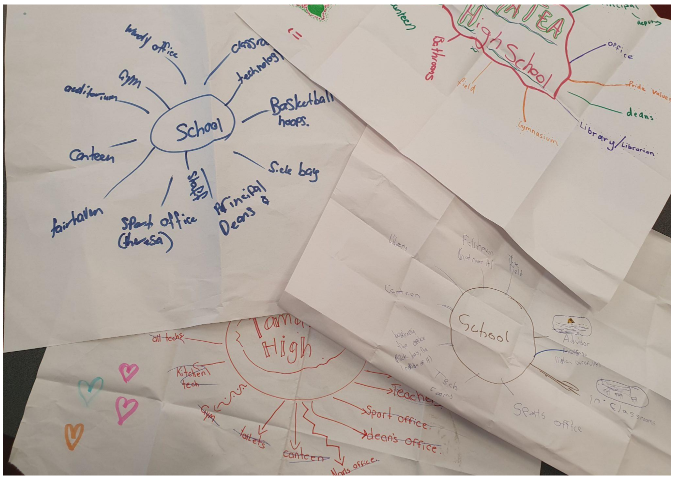

Figure 1: Outcome of brainstorming session by students to identify potential focus.

Moving onto the next phase, the students ideated different ways to solve this problem, drawing on MR to support the solution. The prototype phase resulted in different MR experiences being developed, which included developing digital avatars, AR scavenger hunts and virtual tours. A brief outline of the different experiences created by the students are noted below:

- Digital avatars were created to represent the school and to act as a guide to the AR and VR tours (Figure 2). This activity enabled students to explore concepts of diversity and identity as they debated and considered how this avatar would look and be an appropriate representative of the school.
- An AR scavenger hunt was created by the students to help others locate and learn about the key locations across the school. The students designed these experiences in a collaborative manner, where each student group focused on one location, which was then drawn into one big experience.
- A VR tour of the school was created to provide visitors the ability to explore the school remotely. This was particularly relevant due to the recent situation around COVID-19 and the cancellation of the annual School Information Evening, where potential students visited the school. As with the AR scavenger hunt, each group selected various locations around the school and took 360-degree/panorama photos of these locations (Figure 3), they then developed these into an interactive virtual tour which could be explored in VR (Figure 4 and 5).

With the collaboration from the MPA students, the students delved deep into the project and gained a deep understanding of its cultural significance. Through brainstorming sessions, the students together explored ways to integrate a deeper representation of the school's culture and tikanga (practices and values) and kaupapa (collective vision, aspiration and purpose) into the scavenger hunt and virtual tours. This included adding videos, audio, imagery and knowledge drawn from the MPA class into these experiences. This approach also enabled students to draw on a wider set of knowledge. Students consulted with local iwi and kaumātua (elders), who helped the students to further understand the people, history and surroundings of the school and explored how these ideas expressed in the project could be further widened to move outside of the school and draw in places of significance to the school.

Figure 2: One of the avatar designed by the students to represent the school.

Figure 3: *A 360-degree photo of the school hall taken by a student.*

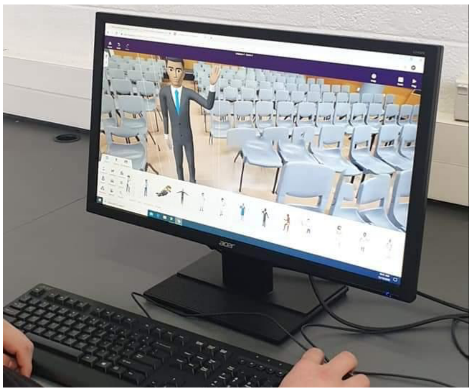

Figure 4: A student developing the virtual tour including interactive components.

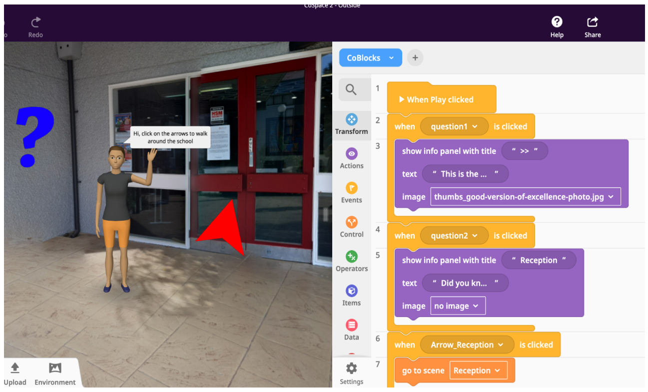

Figure 5: A sample of code that students created to make the tour interactive.

Findings and discussion

In this project MR was adopted in such a way that it reinforced the relationship between physical and digital spaces. In the AR scavenger hunt, the approach provided the ability to link and connect learning to physical spaces and locations, enabling learning to be situational, determined by, and inseparable from, its particular physical and cultural setting (Dunleavy & Dede, 2014). On the other hand, the VR tour brought outsiders into the environment and provided a virtual experience to reinforce an understanding of "place". In this study, MR provided a unique affordance to link people to the environment to enhance their understanding of, and relationship with, the land and its people. The approach meant the culture and the richness of the location could be shared. The incorporation of the MPA students enabled the development of the different artefacts to draw on a richer meaning and move beyond simply application of learning.

> In a school where engagement is a constant challenge, we found that the tools supported students' learning by sparking their curiosity. The Māori Performing Arts students seemed to embrace the technology more intuitively than the digital class because they gravitated towards ways they could use the tools which linked to their interests, experiences and prior learning … rather than thinking, 'oh, this is part of the Digital course and another assessment', the students thought, 'wow, this is novel! This is new and cool!'. (Tania)

The ability of MR to draw in context was especially powerful as it supported learning situated in cultural contexts. However, the application of MR within these cultural contexts was still emerging, especially when explored from a student-created viewpoint. Based on conversations with the teachers, it was clear that the teachers saw the benefits of integrating the two subjects together:

> I liked the thought of sitting [DT] within MPA … [Its integration provided] a more authentic integration of the technology to take learning out of the digital technology classroom and put it in other areas other subject areas … The project helped our team to uncover how enthusiastic our ākonga are to embrace the opportunities that these technologies offer. Students have been incredibly engaged in the process and have found ways in which to use AR and VR to help them understand concepts that would have otherwise been less accessible. Students have been able to build experiences for each other to enrich their learning also; this reinforces a strong sense of mahi tahi, or sharing learning. (Taylor)

> [The way the technology was drawn into the class allowed students to go] into different directions, and required them to take ownership and learn what they didn't know … It supposed learning agency … and differentiating that learning process. (Tania)

Through the applied nature of creating these artefacts, new ways of learning could be supported. Students were able to express themselves and demonstrate their learning in ways that were more exciting and purposeful. The integration of hands-on activities, often drawn into STEM education, has been shown to be highly motivating (Bruce-Davis et al., 2014) and enables students to fully participate in their learning (Margot & Kettler, 2019). As reported by the participant teachers, they saw it as a way for students who weren't necessarily "tech savvy" to drive their own learning and to develop agency. The collaboration between groups helped support this, but the adoption of design thinking meant students led the process, giving them ownership in how they wanted to demonstrate their learning and the direction they wanted to drive their learning. This approach reinforced the belief that design thinking in STEM education enables students to link the development of artefacts with their learning and develop deeper engagement that goes beyond the actual development (Li et al., 2019). As highlighted by Tania, the approach

> enabled problem-solving approaches to be integrated into the class. It was really good to see how students might approach the problem-solving process, and work through this … It was interesting to see how they interacted with that, that whole new process of making a tour. (Tania)

The teachers saw that there was authentic, connected learning around their exposure to VR and AR and that there were key skills that could be developed through application of learning. By applying CT into the MPA class, students drove their own learning, enabling a varied approach to the final solution. This meant that students often needed to come up with their own solutions and thus help others when they encountered issues, especially with the programming of more complex interactions. The teachers were firmly situated as the facilitator of the learning, and the students enjoyed taking leadership and ownership of this process. For example, Matua recounted an experience in his class:

> [In the class when] they are explaining what they are doing with the technology and I say to them, "I don't know what you're talking about". Then we're saying "You gotta do it like this Matua". And they love it, showing us how it works, and joke, "You're supposed to be the teacher" but really they enjoyed it. I sort of trick them into extending themselves by saying "I don't know, can you show me?" They then front up and they owned the learning … It's a different skill of being able to teach the technology. That's what they demonstrate and are getting better at, and not just using [technology] by its part of the learning.

While cross-curricular integration of subjects has been shown to benefit the learner, the effective integration, across subject areas, is often hard to realise. As explored in Garry et al. (2020), the integration of subjects raised significant barriers. Not only do teachers need to reconsider their beliefs about teaching and learning located in individual STEM disciplines, they also need to situate these subjects within these different disciplines. The natural tendency to prioritise their own subject (where they are most comfortable) within the wider approach, means that there are natural contentions where subjects compete for space and relevance (Naidoo, 2010). In this approach, by working together, each teacher was responsible for the learning in their own class. The approach did not detract from each other but rather the context and focus, drawn from the MPA, and the skills, drawn from the DT class, provided the opportunity to extend the learning in each subject.

> There were many different facets to the implementation of MR in a kura, so it is important to share the load. Where possible, we shared ideas and enjoyed co-teaching in each other's classes, using our own strengths to explore the technology and situating the technology more fully within each subject. (Tania)

Moving forward, the teachers plan to support wider uptake with other teachers, with the focus of exposing all junior students to these tools, across different subjects. However, in order to realise this aim, they acknowledge wider buy-in is needed:

> And, you know, it means buy-in from the Senior Leadership Team to say that this is a viable way of learning. Teachers also need to see the value [in how the integration of digital artefacts] can connect two different subjects to increase that motivation and engagement and effective learning. [Support from leadership is needed to provide] space for exploration time in the timetable to allow for [collaboration between teachers and subject]. (Tania)

Conclusion

The approach recounted in this article provides a clear example of how the reconceptualising of how technology is used in the curriculum provided a way to strengthen it. However, the study highlighted that for this to be achieved, there needs to be significant shifts in how technology is viewed and integrated. While this integration provided opportunity for students to apply their learning in more authentic and contextual contexts, it also identified that wider support is needed for teachers to engage learning in this way. Case studies provide an important starting point for teachers to consider the value and role of DT within different subjects and support discussion around the importance of integration and applying DT into different contexts. This case study highlights the importance of developing teachers' digital literacy to identify new opportunities, but also how we can bring DT into different teaching environments in ways that draw on different approaches.

Acknowledgements

This study forms part of a larger research project (Experiences and reflections of teachers on the use of mixed reality technologies to foster cross-curricular learning opportunities) funded by a grant from the New Zealand Teaching and Learning Research Initiative (TLRI).

References

Ananiadou, K., & Claro, M. (2009*). 21st century skills and competences for new millennium learners in OECD countries* (OECD Education Working Papers, No. 41). OECD Publishing. http://dx.doi.org/10.1787/218525261154

Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *The Interdisciplinary Journal of Problem-Based Learning, 6*(2). https://doi.org/10.7771/1541-5015.1349

Bruce-Davis, M. N., Gubbins, E. J., Gilson, C. M., Villanueva, M., Foreman, J. L., & Rubenstein, L. D. (2014). STEM high school administrators', teachers', and students' perceptions of curricular and instructional strategies and practices. *Journal of Advanced Academics, 25*(3), 272–306. https://doi.org/10.1177/1932202X14527952

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented reality in education–cases, places and potentials. *Educational Media International*, *51*(1), 1–15.

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (pp. 735–745). Springer.

Fluck, A. E. (2003). Why isn't ICT as effective as it ought to be in school education? In *CRPIT03: Proceedings of the 3.1 and 3.3 Working Groups Conference on International Federation for Information Processing* (pp. 39–41). Australian Computer Society. http://crpit.com/confpapers/CRPITV23Fluck.pdf

Fluck, A., Webb, M., Cox, M., Angeli, C., Malyn-Smith, J., Voogt, J., & Zagami, J. (2016). Arguing for computer science in the school curriculum. *Educational Technology & Society*, *19*(3), 38–46.

Fox-Turnbull, W. (2019). Implementing digital technology in the New Zealand curriculum. *Australasian Journal of Technology Education*, 5, 1–18.

Garry, F., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020). Understanding K-12 STEM education: A framework for developing STEM literacy. *Journal of Science Education and Technology*, *29*(3), 369–385. http://dx.doi.org/10.1007/s10956-020-09823-x

Gillis A., & Jackson W. (2002). *Research for nurses: Methods and interpretation*. FA Davis.

Guggemos, J. (2021). On the predictors of computational thinking and its growth at the high-school level. *Computers and Education*, *161*. https://doi.org/10.1016/j.compedu.2020.104060

Henriksen, D. (2017) Creating STEAM with design thinking: Beyond STEM and arts integration. *The STEAM Journal, 3*(1), Article 11. http://10.5642/steam.20170301.11

Henriksen, D., Richardson, C., & Mehta, R. (2017). Design thinking: A creative approach to educational problems of practice. *Thinking Skills and Creativity*, *26*, 140–153. https://doi.org/10.1016/j.tsc.2017.10.001

Lesseig, K., Slavit, D., Nelson, T. H., & Seidel, R. A. (2016). Supporting middle school teachers' implementation of STEM design challenges. *School Science and* Mathematics, *116*(4), 177–188. https://doi.org/10.1111/ssm.12172.

Li, Y., Schoenfeld, A. H., diSessa, A. A., Grasser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2019). Design and design thinking in STEM education. *Journal for STEM Education Research*, *2*(2), 93–104. https://doi.org/10.1007/s41979-019-00020-z.

MacCallum, K., & Jamieson, J. (2017). Exploring augmented reality in education viewed through the affordance lens. In E. Erturk, K. MacCallum, & D. Skelton (Eds.), *Proceedings of the 8th Annual Conference of Computing and Information Technology Education and Research in New Zealand*, (pp. 114–120). http://www.citrenz.ac.nz/conferences/2017/pdf/2017-CITRENZ-PACIT.pdf

MacCallum, K., & Parsons, D. (2019, October). Teacher perspectives on mobile augmented reality: the potential of metaverse for learning. In *Proceedings of World Conference on Mobile and Contextual Learning 2019* (pp. 21–28). https://www.learntechlib.org/p/210597

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM Education*, *6*(1), 1–16. https://doi.org/10.1186/s40594-018-0151-2

Ministry of Education. (2017). *Digital technologies | Hangarau matihiko.* https://education.govt.nz/assets/Documents/Ministry/consultations/DT-consultation/DTCP1701-Digital-Technologies-Hangarau-Matihiko-ENG.pdf

Naidoo, D. (2010). Losing the "purity" of subjects? understanding teachers' perceptions of integrating subjects into learning areas. *Education as Change*, *14*(2), 137–153. https://doi.org/10.1080/16823206.2010.518001

Parsons, D., & MacCallum, K. (2020). Comparing the attitudes of in-service teachers to the learning potential of low-cost mobile augmented and virtual reality tools. In *19th World Conference on Mobile, Blended and Seamless Learning (mLearn 2020)* (pp. 33–40. https://www.learntechlib.org/p/218885/

So, H., & Kim, B. (2009). Learning about problem based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of Educational* Technology, *25*(1) https://doi.org/10.14742/ajet.1183

Tikva, C., & Tambouris, E. (2021). A systematic mapping study on teaching and learning computational thinking through programming in higher education. *Thinking Skills and Creativity, 41*, 100849. https://doi.org/10.1016/j.tsc.2021.100849

Wing, J. M. (2006). Computational thinking. *Communications of the ACM, 49*(3), 33–35. https://doi.org/10.1098/rsta.2008.0118