Interdisciplinary Journal of Virtual Learning in Medical Sciences

Brief Report

Integrating Indigenous Knowledge into Science Technology, Engineering, and Mathematics using Virtual Space: A Mission Impossible?

Israel Kibirige[1*]

[1]*Department of Mathematics, Science and Technology Education (DMSTE), University of Limpopo, Polokwane, South Africa*

ABSTRACT

While South African curricula require the incorporation of Indigenous Knowledge (IK) into Science, Technology, Engineering, and Mathematics (STEM), it is not clear what IK educators should include in STEM. The onus is on lecturers to decide what exactly should be taught and what pedagogy to use. The purpose of this discourse is to explore the integration of IK into Western knowledge (WK) using virtual space. The discourse is about the challenges of using virtual space to increase the applicability of IK in STEM subjects at schools and institutions of higher learning. These challenges emanate from IK being tacit and not digitized, place-specific, and incompatibility with WK. The IK knowledge is with custodians who share it with their few selected children, which makes it less accessible to schools. Also, because of a lack of curriculum clarity of what is available either in print or in digital formats that can be taught and assessed, there is a lack of skills in IK teaching, educators' negative attitudes towards IK, and a lack of learning materials to support learning. Despite these challenges, the Information, Communication, Distribution, and Transaction (ICDT) model and the Indigenous Institutional Theory (ITT) can be blended, forming Valorizing Indigenous Knowledge (VIK) to integrate IK in STEM. Hence, the impossible mission can be possible.

Keywords: Integrating, Virtual Space, Curriculum, Indigenous Knowledge, Western Knowledge, Education, Distance

**Corresponding author:*
Israel Kibirige,
Department of Mathematics, Science and Technology Education (DMSTE), University of Limpopo, Polokwane, South Africa.
Email: israelk@ul.ac.za
kibirigei@gmail.com

Please cite this paper as:
Kibirige I. Integrating Indigenous Knowledge into Science Technology, Engineering, and Mathematics using Virtual Space: A Mission Impossible? Interdiscip J Virtual Learn Med Sci. 2024;15(3):214-220.doi:10.30476/ijvlms.2024.100920.1274

Received: 27-11-2023
Revised: 27-05-2024
Accepted: 28-05-2024

Introduction

After independence in 2004, the Cabinet of South Africa advocated the integration of Indigenous Knowledge (IK) in science, Technology, Engineering, and Mathematics (STEM) (1). The IK inclusion comes from the background of earlier curricula that were based on ratio segregation (2). During apartheid, Africans were restricted to "Native Education" through the Bantu Education Act of 1959 (3), while the other races had a different curriculum. Hence, in the dispensation of democratic South Africa, it was necessary to harmonize these curricula to cater for all people regardless of their race to enhance transformation. Jansen and Taylor stated that post-apartheid curriculum reforms address the injustice of apartheid curricula (4).

The transformation started by merging 19 educational departments into a single entity (5). This was followed by the implementation of Curriculum 2005, which was characterized

as the "Outcomes Based Education" (OBE) curriculum (6). In 2002, OBE was replaced by the National Curriculum Statement 2002 (NCS), which was followed by the Revised National Curriculum Statement (RNCS). The latter had many specific aims and focused more on learner activity and administrative dictates that were hard to implement. In 2012, the Curriculum Assessment Policy Statement (CAPS) was introduced as a revision of NCS (7). This new framework streamlined the curriculum by reducing the number of specific objectives from several in previous versions to just three in CAPS. Notably, the incorporation of IK was a requirement across Curriculum 2005, NCS, RNCS, and CAPS.

To implement any curriculum, teachers need to embrace the content. Also, learning materials need to be readily available to support learning. For instance, virtual space could be used to make IK more visible than what it is currently. Virtual spaces provide visualizations of different people engaging in various tasks. Hence, teachers could be trained on how to use virtual space capacities to link with custodians of IK in various communities where they work. To date, IK is not available in virtual space, and teachers are not trained to use it to integrate IK in STEM.

Virtual space based on the ICDT Angehrn's model (8) includes four spaces: Information, Communication, Distribution, and Transaction. Information deals with the visibility of available knowledge. Communication relates to the dissemination or exchange of ideas to various sectors. Distribution is about sending out the available services to wherever they are needed. Transaction is committing to perform a task, and in this model, it is to ascertain that IK knowledge is traded like a commodity, which is the giver and the receiver.

Teachers educated in Western science find it hard to decide which IK in their local area to include in the science curriculum and do not engage in the ICDT model. Consequently, the askew content favours Western science in STEM (9). The IK epistemologies are not incorporated into STEM classes (10, 11), resulting in a gap between what is learned in STEM classes and the knowledge applied in communities (12). The Department of Education has conducted workshops to assist teachers in coping with curriculum changes, but no clear integration of IK into STEM has been laid down for teachers to follow. Also, no learning materials to support the integration of IK into STEM. It is in this backdrop that the author asks: Is using a virtual space-based model to integrate IK into STEM a mission impossible?

Methods

An inductive research design (13) was used in a qualitative approach to literature obtained from Google Scholar related to IK, virtual space, and STEM. The domain and method theories were the theoretical frameworks used to analyze key concepts related to the topic (14). The domain theory was used to draw new perspectives from the selected literature (15), while the method theory enhanced the generation and the use of a model to explain a phenomenon regarding integrating IK into STEM using virtual space.

Results

Placing IK on the Same Level as Western Science

While IK is good to integrate into STEM classes, there are areas where educators are challenged to examine and decide IK's worthiness in the science classroom, especially when there is no model to guide their actions. Educators could use "Knowledge Audits" in their communities to collect information. Knowledge Audits involve an examination of sources of information and the perceptions of unmet needs (16). Auditing knowledge constitutes three components: 1) the process that brought the knowledge into existence, 2) the evaluation of knowledge before it is transferred, and 3) the evaluation of knowledge during and after the transfer (17). Tong (16) suggests that one needs to develop clear strategies like the ten-point strategy to understand and use knowledge effectively. Similarly, the merging of Indigenous

Institutional Theory (IIT) and the ICDT model can offer an avenue for integrating IK into STEM.

Few IK may be used in the science classrooms without modification to elicit myths in that knowledge. A few cases in point are cited in this paper. "The eating of red soil (or ant-hill soil) by expectant mothers improves appetite and enhances the development of the fetus; eating the large African bullfrog, *Pyxicephalus adsperus* (commonly known as *scoco* in siSwati, *tshidula* in Tshivenda, and *segwagwa* in Sepedi - the Moletji area), makes a person to live longer than expected" (18). Educators should refrain from taking IK as myths to develop lessons to use in the science classroom. Again, the challenge is that very little IK is documented because it resides in humans as custodians.

Integrating IK in STEM Institutions

Integrating IK in STEM presents a myriad of insurmountable challenges. IK is tacit knowledge that is difficult to communicate, formalize, and digitize to fit the ICDT model due to its high context-specific and place-specific nature (19). Hence, it is challenging to transfer from one context to another, making it unsuitable for different contexts. Virtual space could be used to show the real context for the receiver to cognate the essence of that IK. Other challenges include a lack of IK-trained teachers, a lack of curriculum clarity regarding what to teach and not teach, educators' negative attitudes towards IK, some areas of incompatibility of IK with Western science, and the absence of learner support materials (18). In addition, there are epistemological issues where IK is gained as subjective acquired as a whole and holistic societal knowledge, while Western science is acquired individually as objective knowledge through experiments. IK uses try-and-error methods to ascertain the efficacy of its knowledge that sustains the community. IK is well understood in the African adages: "It takes a village to raise a child", and "One white ant does not build an anthill" (20), which makes sense when one considers IK in Africa, where the community shares collective roles.

What is often observed in schools is that Western Knowledge (WK) dominates teaching and learning, research, staff development, and student support. It is no wonder educators were unclear as to what was expected of them in teaching and learning in the OBE classroom (21). Some educators are of the opinion that IK should supplement WK, and others think that African IK should just be referred to in a few specified instances, such as when giving examples and names that learners are not familiar with in WK. Such a practice may further alienate the integration of IK knowledge into STEM, cascade low IK in the NCS, and sustain the WK hegemony in STEM.

While debates rage on, it is not just about one issue, but it is a set of lifestyles with dynamic belief systems that sustain communities. Most of the knowledge is with individuals, and it needs to be digitized. Virtual space could be a giant step towards valorizing IK. Also, it is unclear from the NCS and higher education institutions what percentages should be allotted to IK and WK in the science classroom curricula. An ideal model to put IK and WK at the same level of emphasis during curriculum design is shown in Figure 1.

Figure 1 ideal model is in line with IIT (22), which combines two exclusive theories: the Indigenous Knowledge Standpoint Theory (IKST) (23) and the Institutional Theory (IT) (24). IKST consists of a cultural interface, where IK and Western science are used intricately; indigenous agency, where individuals cling to beliefs; and constant tensions involving pressures of the indigenous versus non-indigenous (23). Thus, IKST deals with IK in its holistic and spiritual contexts. Nakata states that "it is a distinct form of analysis and is itself both a discursive construction and an intellectual device to persuade others and elevate what might not have been a focus of attention by others". On the other hand, IIT is a multi-faceted theory (24) that consists of these

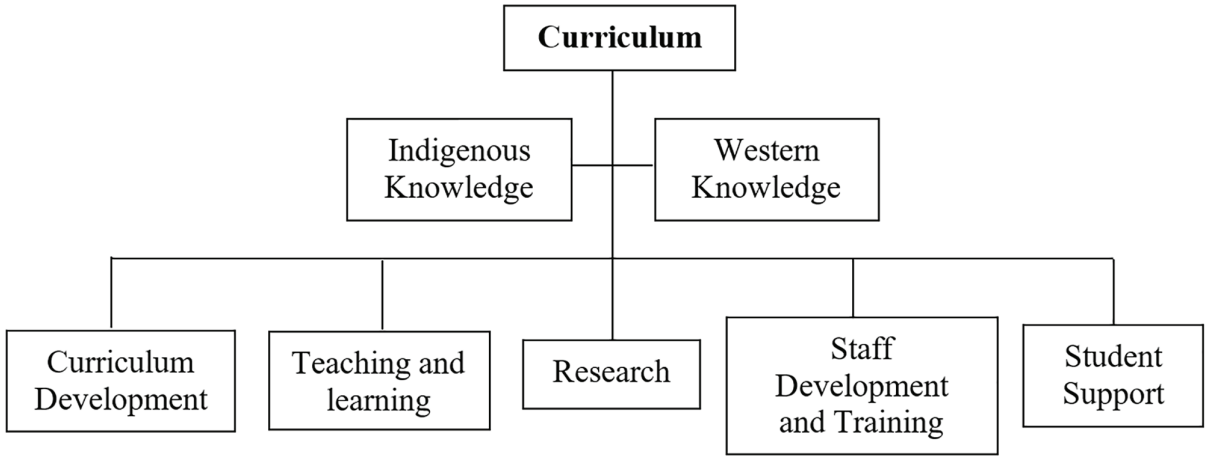

Figure 1: Ideal model depicting similar levels of IK and WK in STEM
*IK: Indigenous Knowledge; WK: Western Knowledge; STEM: Science, Technology, Engineering, and Mathematics

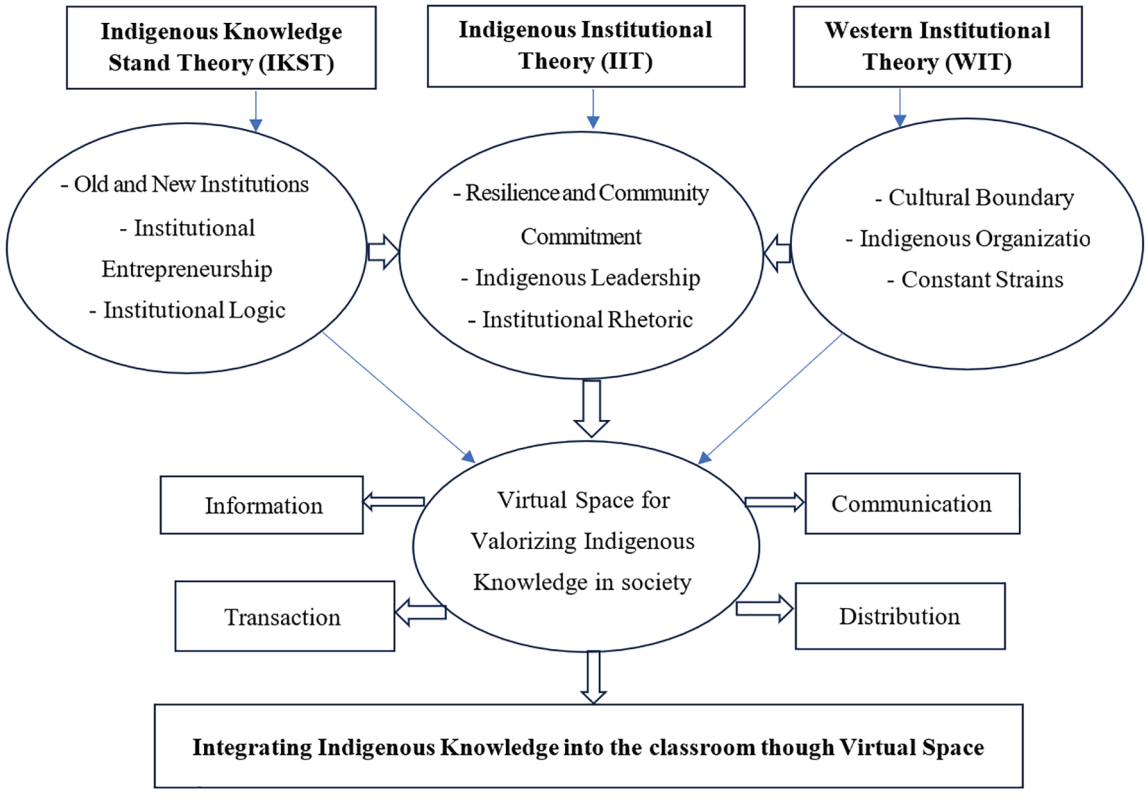

Figure 2: Valorizing Indigenous Knowledge to be integrated into STEM
*STEM: Science, Technology, Engineering, and Mathematics

notions: 1) suppleness and communal commitment, 2) Indigenous governance, and 3) institutional oratory (22). Resilience is crucial for indigenous individuals operating in Western-oriented institutions (25). Although leadership is defined differently, one point that is clear about leadership is striving to make all individuals in an institution reach desired set goals (26). Institutional rhetoric affords the assessment of the institutional agenda regarding IK, which can lead to review processes.

IK information needs to be popularized and valorized, communicated, transacted, and distributed, which are part of ICDT. Both learners and teachers are accustomed to the hegemony of Western science and often underestimate IK (27). Culturally, knowledgeable learners understand the relationship between the African worldviews

and the way that knowledge is formed and used in the community. The challenge is how IK is valorized within the communities. To give you an idea, during the COVID-19 pandemic, some Africans used their IK decoctions to treat COVID-19 symptoms, and lives were saved. To date, such mixtures are not documented and cannot be valorized in a wide community.

The following model aims to popularize IK in STEM (Figure 2). This model deals with Indigenous Knowledge Stand Theory (IKST), Indigenous Institutional Theory, and Western Institutional Theory (WIT). It has been adopted and modified from Angehrn's model (8) and Coates and colleagues' work (20).

Discussion and Conclusion

Is the Integration of IK in STEM through Virtual Space a Mission Impossible?

To develop an understanding of the various IK worldviews that learners bring from their communities, IK needs to be digitized for a large audience. The ICDT can assist teachers in accessing knowledge from IK custodians. For instance, one may use ICDT to learn how to prepare a traditional artefact, such as a clay pot. Teachers using technology could visit the IK custodian to digitize the process of clay pot making. Pot making process can be captured on video, allowing learners to play and replay the video for mastery. This approach will help many science teachers who find it hard to follow heuristic approaches that engage learners in investigations and inquiry-based studies (28).

Therefore, virtual space can be used to integrate IK into STEM. The bottleneck is the unavailability of IK. The author proposed a model for integrating IK into STEM. It is essential to note that different parts of the globe have their IK. Hence, the author's question is cosmopolitan. The answer to the question is: The mission is possible if the valorization of IK is implemented within the community and beyond. In addition, Virtual Reality (VR) blends well with virtual space and can be used to promote IK and improve learners' motivation (29). Moreover, VR enhances disabled undergraduate students (30), suggesting that it is useful for inclusivity in dealing with gender and disabled learners and their needs. Thus, the way forward is to establish virtual space IK learning materials based on the valorizing model to enhance pre-service teachers' IK. Since there are no questions set on IK in high-stakes tests in Grade 12, there is a need to include IK in the high-stakes assessments in the ratio of 50:50 between IK and Western science. This paper's contribution involves integrating IK STEM and popularizing IK to be included in STEM high-stakes examinations. This can motivate learners and teachers alike to take IK in their communities seriously. Virtual space has the potential to enhance STEM teaching and to ascertain how IK from different communities around the globe can be shared within and between communities.

This discourse advocates the use of virtual space to learn and teach STEM. It suggests that the VIK model can enhance the integration of IK into STEM. As technology becomes more widespread in South African villages, as well as the indigenous populations of Alaska, Canada, Maori, Australia, and other places, the impact of VIK will be inevitable. The author contends that the use of virtual space through VIK can enhance the integration of IK into STEM and, hence, a possible mission.

Abbreviations

IK: Indigenous Knowledge
WK: Western Knowledge
STEM: Science, Technology, Engineering, and Mathematics
ICDT: Information, Communication, Distribution, and Transaction model
ITT: Indigenous Institutional Theory
VIK: Valorizing Indigenous Knowledge
OBE: Outcomes Based Education
NCS: National Curriculum Statement
RNCS: Revised National Curriculum Statement
CAPS: Curriculum Assessment Policy Statement
IKST: Indigenous Knowledge Standpoint Theory
WIT: Western Institutional Theory
VR: Virtual Reality

Acknowledgments

The author acknowledges the University of Limpopo for providing the resources and facilities used in drafting and revising the manuscript.

Authors' Contribution

IK conceptualized the study and completed the entire process until submission, including revising and responding to comments. He takes full responsibility for the content and writing of this article.

Conflict of Interest

The authors have no conflict of interest.

Funding/Support

No funding or support was received.

Availability of Data and Materials

All data supporting the discourse can be obtained from articles where DOIs are provided and from books and book chapters available online.

References

1 Green LJF. The Indigenous Knowledge Systems Policy of 2004: Challenges for South African Universities. Social Dynamics. 2017;33(1):130–54. doi: 10.1080/02533950708628746.

2 Msila V. From Apartheid Education to the Revised National Curriculum Statement: Pedagogy for Identity Formation and Nation Building in South Africa. NJAS. 2007;16(2): 146-160. doi: 10.53228/NJAS.v16i2.63.

3 Tabata IB. Education for Barbarism. University of Michigan: Pall Mall; 1960.

4 Jansen J, Taylor N. Educational Change in South Africa 1994-2003: Case Studies in Large-Scale Education Reform. Country Studies Education Reform and Management Publication Series. 2003;2(1):1-47. Available from: https://documents1.worldbank.org/curated/en/129941468778149162/pdf/282500PAPER0Ed1outh0Africa01Public1.pdf

5 Motala E. Transformation of the South African schooling system. The Centre for Education Policy Development (CEPD): Braamfontein; 2017.

6 Harden RM. AMEE Guide No. 14: Outcome-based education: Part 1-An introduction to outcome-based education. Med Teach. 1999;21(1):7–14. doi: 10.1080/01421599979969.

7 Pinnock A J E. A practical guide to implementing CAPS: A toolkit for teachers, school managers and education officials to use to assist in managing the implementation of a new curriculum. Alexandra: NAPTOSA; 2011.

8 Angehrn A, Designing mature Internet business strategies: the ICDT model. Eur Manag J. 1997;15(4):361-9. doi: 10.1016/S0263-2373(97)00016-9.

9 Madiope M, Mendy J. Curriculum transformation: A case in South Africa. Perspectives in Education. 2020;38(2):1-9. doi: 10.18820/2519593X/pie.v39.i1.1.

10 Ngubane NI, Makua M. Intersection of Ubuntu pedagogy and social justice: Transforming South African higher education. Transformation in Higher Education. 2021;6(1):1-8. doi: 10.4102/the.v6i0.113.

11 Moremoholo TP. The Role of Culture in Shaping the Curriculum of Higher Education in South Africa. JCSR. 2023;5(2):37-55. doi: 10.46303/jcsr.2023.17.

12 Kaya HO, Seleti YN. African indigenous knowledge systems and relevance of higher education in South Africa. The International Education Journal: Comparative Perspectives. 2013;12(1):30-44. Available from: https://files.eric.ed.gov/fulltext/EJ1017665.pdf

13 Tamene EH. Theorizing Conceptual Framework. Asian Journal of Educational Research. 2016;4(2):50-6. Available from: https://ju.edu.et/education-and-behavioral-science/wp-content/uploads/sites/5/2023/01/THEORIZING-CONCEPTUAL-FRAMEWORK.pdf

14 Jaakkola E. Designing Conceptual Articles: Four Approaches. AMS review. 2020;10(1):18-26. doi: 10.1007/s13162-020-00161-0.

15 Lukka K, Vinnari E. Domain theory and method theory in management accounting research. Accounting, Auditing & Accountability Journal. 2014;27(8):1308-38. Available from: https://www.emerald.com/insight/content/doi/10.1108/AAAJ-03-2013-1265/full/html.
16 Tong T. Ten steps toward effective knowledge audits. Knowledge Management Review. 2005;8(3):1-5. Availabe from: https://primo.qatar-weill.cornell.edu/discovery/fulldisplay?context=PC&vid=974WCMCIQ_INST:VU1&search_scope=MyInst_and_CI&tab=Everything&docid=cdi_proquest_reports_217490092
17 Dinur A. Tacit knowledge Taxonomy and Transfer: Case-based Research. Journal of Behavioral and Applied Management. 2011;12(3):246–81. doi: 10.21818/001c.17865.
18 Kibirige I, Van Rooyen H. Enriching science teaching through the inclusion of indigenous knowledge. IK in the science classroom, in de Beers, J & van Rooyen, H (eds), Teaching science in the OBE classroom, Johannesburg: MacMillan; 2007; P. 235-247.
19 Jessen TD, Ban NC, Claxton NX, Darimont CT. Contributions of Indigenous Knowledge to ecological and evolutionary understanding. Front Ecol Environ. 2022;20(2):93-101. doi: 10.1002/fee.2435.
20 Semali LM, Kincheloe JL. Introduction: What is indigenous knowledge and why should we study it? In: Kincheloe J, editor. What is indigenous knowledge? New York: Routledge. 1999; P. 3-57.doi: 10.4324/9780203906804.
21 Sanders M. What exactly do I have to do? Understanding the requirements of the new curriculum. Proceedings of the South African Association of Science and Technology Educators; 2006 Jul 3-6; Durban, South Africa.
22 Coates SK, Trudgett M, Page S. Indigenous institutional theory: a new theoretical framework and methodological tool. Aust Educ Res. 2023;50(3):903-20. doi: 10.1007/s13384-022-00533-4.
23 Nakata M, Disciplining the savages, savaging the disciplines. Aboriginal Studies Press: Canberra; 2007.
24 Lammers JC, Garcia MA. Institutional theory approaches. The International Encyclopedia of Organizational Communication. 2017;1–10. doi: 10.1002/9781118955567.wbieoc113.
25 1. Ryan T, Evans M. The wisdom of differentiating between Indigenous leader and Indigenous leadership. In: Intezari A, Spiller C, Yang S ying, editors. Practical Wisdom, Leadership and Culture - Indigenous, Asian and Middle-Eastern Perspectives. 1st ed. Routledge; 2021.
26 Gottfredson RK, Reina CS. Exploring why leaders do what they do: An integrative review of the situation-trait approach and situation-encoding schemas. The Leadership Quarterly. 2020;31(1):101373. doi: 10.1016/j.leaqua.2019.101373.
27 Masoga M. How indigenous is the Bible? Challenges facing 21st century South African biblical scholarship. Journal for Semitics. 2004;13(2):139-58. Available from: https://hdl.handle.net/10520/EJC101034
28 Horak E, Fricke I. Building Capacity by Mentoring Mathematics and Science Teachers. Proceedings of the 8th Conference on Asphalt Pavements for Southern Africa (CAPSA'04); 12–16 September 2004; Sun City, South Africa. Available from: https://www.researchgate.net/publication/228949598_Building_capacity_by_mentoring_mathematics_and_science_teachers
29 Rodolico G, Hirsu L. Virtual Reality in education: supporting new learning experiences by developing self-confidence of Postgraduate Diploma in Education (PGDE) student-teachers. EMI Educ Media Int. 2023; 60:2, 92-108. doi: 10.1080/09523987.2023.2262195.
30 Chen PH, Ho HW, Chen HC, Tam KW, Liu JC, Lin LF. Virtual reality experiential learning improved undergraduate students' knowledge and evaluation skills relating to assistive technology for older adults and individuals with disabilities. BMC Medical Education. 2024;24(1):101. doi: 10.1186/s12909-024-05085-y.