Assessing the Effect of Curricula Variation in Mathematics Teacher Education on Teaching Competency

[1]Jimmy Ezekiel Kihwele*, [2]Fred Mgata

[1]Faculty of Social Sciences, Mzumbe University, P.O. Box 5 Mzumbe, Tanzania

[2]Center for Teacher Education Research, Beijing Normal University, No. 19 Xinjiekouwai Street, Haidian District, Beijing, China

E-mail: jikihwele@mzumbe.ac.tz

ARTICLE INFORMATION

Article History

Received: 19th May 2023
Revised: 13th September 2023
Accepted: 20th September 2023
Published: 02nd December 2023

Keywords

Mathematics
Teacher education
Subject-matter expertise
Curricula variation
Tanzania

ABSTRACT

Curriculum development processes at universities are decentralised, resulting in varying subject-matter mastery levels among graduates. The paper examined the effect of teacher education curricula variation on mathematics teachers' competencies. The study employed a case study design with 18 mathematics teacher graduates from nine teacher education institutions working in the Manyara region. The study used in-depth interviews, open-ended questionnaires, and documentary review methods to collect data. The findings revealed that despite mathematics teachers' mastery of the subject matter, their competence slightly varied in some topics. There are mismatches between courses at different universities and topics in secondary schools that affect teaching competencies among teachers. Decentralised curriculum development at teacher training institutions results in dissonant curricula that produce different qualities in teachers. Despite various capacity-building mechanisms, teachers inadequately elevate their competencies. The study recommends the development of compulsory modules across teacher education institutions to reflect secondary curriculum requirements.

*Corresponding author's e-mail address: jikihwele@mzumbe.ac.tz (Kihwele, J.E)

1.0 Introduction

The quality of teachers has a direct impact on students' interest and motivation in learning and performance (Bar-Tal et al., 2020; Kaiser & König, 2019; Moh’d et al., 2021). Teachers’ subject-matter expertise influences their instructional practice, teachers’ self-efficacy, and student learning achievement. Since teacher knowledge directly affects student achievement, it is reasonable to view teacher preparation as a primary reform lever (Fischer et al., 2020; Tazitabong, 2021). Well-trained and competent teachers in subject matter and pedagogy can design lessons that effectively influence student learning (Moh’d et al., 2021). However, the teacher-training curriculum across countries and institutions is decentralised, resulting in different quality products for trained teachers (Pryor et al., 2012; Qadhi &Alkubaisi, 2022). Different qualities of trained teachers lead to variations in classroom instructional practices and students’ learning (Kaiser & König, 2019). Hence, it calls for critically examining teacher education curricula variations and their effect on mathematics teachers’ competencies.

PISA-2015 results show that mathematics performance was lower compared to reading and science results (OECD, 2016). Ker (2013) analysed the trend of mathematics achievement using TIMSS data and found that although achievement improved over time, students’ abilities in mathematics deteriorated. Moreover, Sa’ad et al. (2014) reported a trend of poor mathematics performance in Nigeria due to unqualified teachers using weak pedagogy, among other reasons. Likewise, in Malaysia, Wong and Wong (2019) report that low interest in mathematics among students causes a performance decline. Furthermore, Murray (2013) says teachers’ failure to translate mathematics concepts from textbooks accordingly and help learners learn quickly contributed to the 65% failure rate.

Tanzania has no exception to the challenge of mathematics achievement, like other countries. According to the National Examination Council of Tanzania reports, from 2016 to 2020, the general performance of Form Four national mathematics examinations has been poor for five years. In this period, the number of students who achieved passing grades was below 25%. For example, students who obtained grades A to D (100%–30%) ranged from 18.12% (of 349,202 students) in 2016 to 20.12% (of 435,345 students) in 2020 (National Examination Council of Tanzania, 2022). The trend of poor performance in the subject calls for analysis to understand the root cause.

1.1 Teacher Education Curriculum

Teacher education curricula across universities in several countries, such as Germany, the US, Romania, and Singapore, have some elements of similarity and dissimilarity in their curriculum components (Cochran-Smith et al., 2020; Flores, 2016; Kotthoff & Terhart, 2013; Tay & Kaur, 2021). In German, Kaiser and König (2019) and Kotthoff and Terhart (2013) report that there is a diversification in teacher education curricula where the structures of programmes are mainly heterogeneous, particularly in their focus on academic subjects, profession-oriented studies, and internship schedules. Despite the diversification, there has been an attempt to standardise and harmonise teacher education by developing core curricula that enforce obligatory modules, competencies, and contents for all subjects that will eventually shape teacher education. Likewise, the teacher education curriculum in different states in the US is similar yet has diversified features. Student teachers attend two-semester internships and have teacher professional development partnerships with schools to promote teaching ability (Cochran-Smith et al., 2020). The opportunity to practice and collaborate in learning allows student teachers to develop similar knowledge of the mathematics subject matter and mastery of pedagogical skills (Wang et al., 2020). Additionally, in Singapore, there are differences among teacher education programmes in terms of contents, even though all student teachers are required to do compulsory independent learning to cover mathematics topics at the secondary education level using school textbooks and relevant materials (Tay & Kaur, 2021).

The demand for high-quality teachers escalates the need for teacher education institutions to provide relevant learning opportunities to foster appropriate professional competencies and skills for teachers to succeed in their responsibilities (Kotthoff & Terhart, 2013). However, teacher preparation opportunities face the challenge of curriculum dissimilarities across universities. In Tanzania, university teacher education curricula are decentralised despite the regulations from Tanzania Commissions for Universities (TCU) to set minimum standards requirements (Nyamwesa et al., 2020). Although universities develop curricula after conducting a need assessment with crucial stakeholders, the TCU is responsible for approving whether they reflect the needs and adhere to national guidelines, policies, and vision (Nyamwesa et al., 2020). Despite the comprehensiveness of curriculum development, the decentralised model results in fragmented curricula from one university to another. Again, the decentralised model of developing curricula results in differences in teacher quality but with similar qualifications (Pryor et al., 2012).

1.2 Curricula Fragmentation and its Effect

Evidence shows that there are curricula variations in some countries that affect the quality of teacher preparation (see Cochran-Smith et al., 2020; Kaiser & König, 2019). In Germany, the fragmentation of teacher education is one of the reported challenges facing the quality of teachers (Kaiser & König, 2019). Student teachers are more oriented towards the core academic discipline than the corresponding syllabi at the secondary level, where they are prepared to teach (Cochran-Smith et al., 2020; Kotthoff & Terhart, 2013). Although student teachers conduct teaching practicum as a requirement for professional training, some evidence suggests that school-based field practices are not necessarily the panacea for improving pedagogy and subject knowledge (Kihwele & Mattandi, 2020).

Access to the profession is traditionally granted based on grades obtained, with the assumption that these grades have a prognostic significance for later professional success. However, the struggle of novice teachers to cope with their careers shows that the university teaching knowledge acquired is not directly linked to the profession’s needs and forces self-regulation to adapt to school contexts (Kotthoff & Terhart, 2013). Newly qualified teachers face different levels of professional stress and insecurity in transitioning from university to teaching (Bar-Tal et al., 2020). Teachers often need help adapting to the professional practice and competence level they experience through working with and observing their colleagues (Bar-Tal et al., 2020; Pryor et al., 2012). Thus, the teacher education curricula must be well harmonised to provide student teachers with an exceptional opportunity to directly link important parts of teacher education to school practice and the development of their careers (Kajoro, 2016; Kotthoff & Terhart, 2013). Relevant teacher education curricula encourage newly qualified teachers to spend less time adjusting to the school context through different professional development avenues and self-regulation mechanisms (Damşa et al., 2021).

1.3 Mathematics Pedagogical Content Knowledge (MPCK)

Mathematics pedagogical content knowledge (MPCK) encompasses mastery of content knowledge and appropriate methods of understanding learners for instruction facilitation (Gasteiger et al., 2020; Venkat & Adler, 2014). Venkat and Adler (2014) further show that two model constructs involve common content knowledge (CCK) and specialised content knowledge (SCK), which primarily depend on teacher training. Teacher education programmes aim to equip teachers with instructional knowledge that facilitates student learning (Bar-Tal et al., 2020; Flores, 2016). Student teachers are to develop professional abilities such as subject content knowledge, and PCK delivers lessons that reflect potential meaning(s) for their future students (Flores, 2016; Werler & Tahirsylaj, 2022). However, the mathematics teacher education curriculum is institution-oriented, with institutions taking precedence, leading to variations in curricula (Cochran-Smith et al., 2020; Kaiser & König, 2019). Bussey et al. (2013), in their Exploring Variation Theory, claimed that experience variations result in differences in learning. The theory provides three learning spaces: an intended object of learning, an enacted object of learning, and a lived object of learning (Kullberg et al., 2017). What is intended might differ from what is enacted, and student teachers' understanding of the enacted influences their future instructional skills (Bussey et al., 2013). Given the variation in teacher training curricula across institutions, student teachers' learning outcomes in MKT and MPCK tend to vary (Werler & Tahirsylaj, 2022). In this context, the model MPCK helps to understand the effect of variation in teacher education curricula on mathematics teachers' content knowledge and pedagogical skills.

1.4 Statement of the Problem

Globally, the trend of mathematics performance has been falling behind other subjects, despite the subject being core in the scientific and technological revolution era. In Tanzania, for the past five years, the number of students who pass mathematics in the Form 4 national examination is far below 25% of total candidates (National Examination Council of Tanzania, 2022). Concerns about these poor results raise questions about whether mathematics teaching is as efficient as it should be. Similarly, there is concern about the competence of teachers from varied teacher education programmes to assume their mathematics teaching role effectively (Mazana et al., 2023). Even though there are different initiatives and innovations to improve mathematics teaching (see Kihwele & Mgata, 2022; Kihwele &Mkomwa, 2023; Yeh et al., 2019), mathematics teacher education curricula are worth an examination to determine the quality of mathematics teachers produced. Therefore, this study is intended to examine teacher education curricula variation and its effect on mathematics teachers' competencies. The research questions are: How do teacher education curricula vary in preparing teachers to teach secondary school mathematics syllabi? How does teacher education curriculum variation affect students' performance? What are the coping mechanisms among mathematics teachers to harmonise the emerging content knowledge variations to enhance students' performance?

2.0 Materials and Methods

2.1 Study Design

The study employed a case study design to analyse the case or unit of focus by collecting information and describing the findings under the emerging themes (Creswell, 2014; Denzin & Lincoln, 2018). The selected design was appropriate for examining how teacher education curricula vary, and how their effect on enhancing teachers' competencies to implement secondary school mathematics syllabi. The study was conducted during the field visit, where researchers interviewed mathematics teachers to obtain information concerning the harmony of teacher education curricula and secondary school curricula. Further, the study employed multiple data collection methods, including questionnaires and document reviews, to ensure that the data were trusted, dependable, and credible.

2.2 Participants

The study involved eighteen (18) in-service mathematics teachers from eleven (11) public and private secondary schools from three districts, namely Babati, Mbulu, and Hanang, in the Manyara region of Tanzania. These teachers completed their bachelor's degrees in education from nine (9) universities between 2008 and 2019. Respondents have been teaching mathematics since they graduated from university. Researchers used snowball-sampling techniques to ensure access to the desired sample for the study (Saunders et al., 2016). Researchers met with respondents during the teaching practice assessment, visiting the schools in three districts.

2.3 Data Collection Method and Analysis

The data collection methods involved in-depth interviews with eight (8) participants on content-based challenges they face in teaching mathematics. The interview asked mathematics teachers about mathematics topics from ordinary-level mathematics syllabi that are challenging to teach and the possible reasons for their difficulties. Also, the interview questions require matching courses they studied at their university corresponding to ordinary secondary mathematics topics from the list. The other ten (10) teachers preferred to fill out open-ended questionnaires. Researchers obtained their oral consent before they participated in giving information. Moreover, the study reviews some documents involving the ordinary-level mathematics syllabus, certificate of secondary education examination formats, and results from NECTA. Manual data analysis involved coding and categorising information, resulting in themes presented in line with research questions and simple descriptive statistics.

3.0 Results and Discussion

The study investigated the impact of different teacher education curricula on the proficiency of mathematics teachers. The objective was to identify the discrepancies in mathematics curricula within teacher education programmes and examine how these discrepancies affects the execution of the secondary school mathematics curriculum.

3.1 Variation of Mathematics Teacher Education

The findings reveal that teachers have mastered most of the topics required to teach in secondary schools (see Appendix 1), despite variations in the content covered at the university. The variations are depicted through the mismatch between mathematics topics covered at respective universities concerning the topics in the secondary school curriculum. Teachers believe the main factor in the mismatch is the dissimilarity of teacher education curricula used to train them at respective training institutions (Kaiser & König, 2019). As they did not cover some topics during university, it affected the quality of teachers and teaching (Kaiser & König, 2019; Singh & Shakir, 2019). Likewise, teachers mentioned the topics they perceive are challenging to teach as they hardly covered their content at the university (see Table 1). The incompetency lowered teachers' self-efficacy in teaching those topics towards implementing the ordinary-level mathematics curriculum (Lauermann & ten Hagen, 2021).

To examine further the variation in teacher education curricula, the analysis compared mathematics teacher preparation curricula from University A and University B, which found variations in their competency to teach topics of different classes (see Appendix 1). Teachers admit they have not mastered 100% of secondary school topics, jeopardising students' learning and performance. The findings resonate with Kaiser and König (2019), who found a variation in teacher education curricula produced teachers with different qualities. Although teachers from University A showed higher mastery of mathematics topics in all classes they taught, teachers from University B admitted to a need for more content knowledge of some core topics in the ordinary-level mathematics curriculum. The negative impact of curriculum variation in teacher training programmes necessitates the development of homogenous modules that shall be core for all teacher preparation institutions.

Table 1
Comparison of Challenging Topics by Graduates from Institutions they Graduate

SN	Institution	Frequency	Challenging Topics from O-Level Mathematics Curriculum (Form)
1	University A	3	Accounts, Circles, Earth as a Sphere, Relations and Functions (Form 3), Probability and Three-dimensional Figures (Form 4), and Logarithms (Form 2)
2	University B	5	Probability and Three-dimensional figures (Form 4), Circles and Accounts (Form 3)
3	University C	2	Probability (Form 4) and Account (Form 3).
4	University D	1	Probability (Form 4), Algebra (Form 1 & 2)
5	University E	1	Probability (Form 4)
6	University F	2	Logarithms (Form 2), Earth as the sphere (Form 3), and Three-dimensional figures (Form 4)
7	University G	1	Geometric Transformations (Form 2).
8	University H	2	Circles and Earth as a sphere (Form 3).
9	University I	1	Circles and Earth as a sphere (Form 3).

3.2 Effects of Teachers' Competence Variation on Students' Performance

The second research question sought to understand how the variation in preparing teachers leads to a variation in teachers' competencies that affect student-learning performance. The findings revealed that teachers had limited mastery of some topics due to curriculum variation, leading to challenges in teaching those topics. Venkat and Adler (2014) opined that teacher training enhances subject-specific content among teachers. In this context, teachers perceive that teacher education institutions trained them partially, resulting in their incompetence in teaching some topics. Some teachers revealed that the teaching context forced them to use the knowledge acquired in their secondary education rather than what they learned at universities.

Through the documentary review, the study further scrutinised the certificate of secondary education examination formats to understand the required topics for the final examination. The format revealed numerous topics that mathematics teachers admitted to being challenging to teach as part of the assessment structure. Table 2 shows the topics and the weight or number of questions each topic constitutes for the Form Four national examination.

Tab 2

Table of Specifications for Mathematics Subject in National Examination Format

SN	Topic	Number of Items per Topic	Percentage Weight per topic
1	Numbers/Fractions, Decimals and percentages/ Approximations	1	7.14
2	Exponents/Radicals/Logarithms	1	7.14
3	Sets/Probability	1	7.14
4	Coordinate geometry/Vectors	1	7.14
5	Geometry/Perimeters and areas/Congruence and similarity	1	7.14
6	Units/Rates and variation	1	7.14
7	Ratios, profit and loss/Accounts	1	7.14
8	Sequences and series	1	7.14
9	Trigonometry and Pythagoras' theorem	1	7.14
10	Algebra/Quadratic equations	1	7.14
11	Statistics/Circles	1	7.14
12	Three-dimensional figures/The Earth as a sphere	1	7.14
13	Matrices and transformations	1	7.14
14	Linear Programming /Functions/Relations	1	7.14
Total Number of Items		**14**	
Total Percentage Weight			**100**

The findings imply that students sit for the national examination without mastering some topics, and their teachers face challenges in teaching. The topics teachers admitted were challenging to teach are the core topics in the national examinations. In this situation, students can hardly score higher when unprepared for all topics. The findings echo the study of Blömeke et al. (2020) and Venkat and Adler (2014), who report that some teachers face challenges in teaching some topics depending on how teacher training prepared them.

In light of the above finding, the study explored the mathematics performance trend of the schools visited to ascertain the link between teachers' confidence and ability to teach and what students achieve in national examinations. The analysis results indicated a poor performance trend in most schools—for example, the average performance for the past five years (see Table 3). The findings resonate with Singh and Shakir (2019), who asserted that poor mastery of content knowledge and low self-efficacy among teachers affects students' performance negatively. Despite the performance trend improving from 26.7% in 2019 to 33.5% in 2021, Ker (2013) cautions that although performance can improve over time, students' abilities in the subject can deteriorate. Therefore, the need to enhance the quality of teaching, especially in teacher education, is vital.

Tab 3
Mathematics Performance Trend in the Visited Schools

School	Type	Performance trend in 5 years														
		2022			2021			2020			2019			2018		
		Total	Pass	% Pass	Total	Pass	% Pass	Total	Pass	% Pass	Total	Pass	% Pass	Total	Pass	% Pass
S1	Private	111	86	77.5	110	99	90	164	122	74.4	130	98	75.4	127	86	67.7
S2	Public	120	27	22.5	161	31	19.5	133	15	11.3	157	15	9.6	102	21	20.6
S3	Public	27	5	18.5	28	9	32.1	31	6	19.4	21	1	4.8	17	1	5.9
S4	Public	121	27	22.3	113	15	13.3	103	20	19.4	66	15	22.7	63	12	19
S5	Public	62	12	19.4	55	11	20	55	11	20	28	3	10.7	22	9	40.9
S6	Public	43	10	23.3	39	1	2.7	48	9	18.8	37	7	18.9	10	2	20
S7	Public	130	12	9.2	102	12	11.8	105	8	7.6	94	13	13.8	67	8	11.9
S8	Public	140	40	28.6	135	23	17	135	43	31.9	124	20	16.1	107	21	19.6
S9	Private	101	14	13.9	96	29	30.2	87	12	13.8	71	8	11.3	69	10	14.5
S10	Public	100	11	11	116	5	4.3	95	12	12.6	N/A	N/A	N/A	N/A	N/A	N/A
S11	Public	205	144	70.2	146	134	91.8	149	89	59.7	131	49	37.4	130	29	22.3
Average Pass %				**33.4**			**33.5**			**31.4**			**26.7**			**27.9**

3.3 Teachers Coping Mechanism to Harmonize the Emerging Variations

The third research question explored mechanisms mathematics teachers employ to fill the knowledge gap and acquire the competencies they lack to facilitate mathematics learning in schools. Findings show mathematics teachers are using their knowledge differences and teamwork at school as crucial ingredients for improvement. The findings reveal teachers' pedagogical flexibility, self-practices, and collaboration strategies.

3.3.1 Teachers' Collaborative Learning

The study found that in some cases, mathematic teachers collaborated in learning communities through convenient platforms such as social media groups and informal meetings at specific schools. The first type of collaboration was through WhatsApp groups, where one teacher admitted that the group invited mathematics teachers from different schools, and they started when they were at the university. The findings are similar to those of Kihwele and Mgata (2022), who found that teachers use online platforms, particularly WhatsApp, to learn from each other and elevate their content knowledge and pedagogical skills. The group helps them share some teaching and learning materials, including links to websites to access materials or online lecturers, to enhance their content knowledge. A teacher in school 2 reported that:

> I am a member of the mathematics teachers' WhatsApp group. The group has 244 members from different schools in the country. We share various resources; we respond to challenging issues concerning teaching mathematics. Members can ask or share whatever is within the group's scope, especially complex mathematics questions. In some contexts, we set exam questions, and each teacher administers them to their students (Teacher 2A).

Another type of collaboration was informal meetings in some schools. Teachers revealed that several mathematics teachers in one school tend to meet and discuss challenging topics and how to teach them. Since they studied at different universities, their differences in competencies benefit each other and enhance their content knowledge. The findings reveal that teachers acknowledge that these informal meetings help them exchange their understanding and boost their self-efficacy during classroom teaching. A teacher in school 1 revealed, "Before teaching, I must sit with my colleagues at the department so that we train ourselves to clarify the topic, and when I am ready, then I go to teach in the classroom." The findings resonate with Inprasitha (2015), who reported that teachers at the school level conduct meetings and workshops through lesson study to share their teaching experience and help each other improve subject matter knowledge and pedagogical skills. However, Inprasitha further asserts that effective collaboration among teachers for learning depends on the culture and behaviour among teachers. In contrast, collaborative learning can hardly occur if there is seclusion.

Teachers of mathematics also acknowledged asking one another for help on some of the more difficult topics. Less experienced teachers favour peer teaching to advance their competences, according to Moliner and Alegre (2022). While they concede that this occurs when there is a positive rapport between maths instructors and self-assurance in admitting that some subjects are difficult and need for help. A teacher from school 8 confirmed this finding as he revealed that:

> When the topic is challenging, I invite my colleague to teach it, even if we teach in different classes. Initially, I felt it was hard to admit to others that this topic was complex, but later, I realised my colleagues face similar situations. Luckily, we graduated from different universities and worked closely as a team (Teacher 8B).

3.3.2 Pedagogical Flexibility

Pedagogical flexibility means teachers adjust the methods, strategies, and approaches to delivering the lesson in the classroom. Mathematics teachers revealed they engaged strategies such as re-organising the contents from simple to complex, where they had adequate time to prepare as they proceeded with teaching. Teachers also employed a learner-centred approach to allow students to work on given assignments and share them in the classroom. Teachers admitted that some students tend to attend private lessons during their holidays. In this view, these students might have understood the topics, so they can easily share their understanding through learner-centred approaches. In addition to a learner-centred approach, teachers used questions and answers to encourage those who understood to share their knowledge with others. The questions and answers also involved questions from past national examinations. The findings are similar to those of Kihwele and Mkomwa (2023), who found that teachers use innovative methods to support their teaching. Also, Inprasitha (2015) revealed that teachers use lesson-study approaches innovatively and collaboratively to enhance their knowledge and skills for effective teaching.

3.3.3 Self-study and Practices

To fill the knowledge gap and smooth the teaching process, teachers revealed they self-studied some topics and practiced mathematics questions. In self-studying, teachers search for books or ask for relevant books from their colleagues to help them understand the topics well before delivering them to classroom students. One teacher from school 7 confirmed the finding, saying that “I can manage the topic through reading different textbooks and sharing ideas with other teachers about the difficulty sub-topic where they give me or recommend the suitable books." However, some teachers admitted to teaching even if they had not mastered the content. They only use the previous experience they acquired when they were at the same level of studying as they are teaching now (Moh’d et al., 2021). Also, teachers admit that sometimes it requires adequate time to find and read suitable materials, but it helps boost their skills, knowledge, and confidence to teach such topics.

Again, a few teachers acknowledged that they spent some time practicing some calculations from the challenging topics before entering the classroom to teach. Some respondents, however, revealed that the likelihood of them mastering the content through self-practice is small compared to how it could be if they were trained well at the university (Mahmud et al., 2022). In confirming this finding, a teacher from school 3 said, “I also practice and solve various mathematical problems, at least to show I master the subject contents despite feeling less confident." Despite the benefits of self-study practices, they might only be helpful if a teacher knows the concepts or calculations the students must learn.

4.0 Conclusions and Recommendations

The study examined the teacher education mathematics curriculum’s compatibility with the secondary school mathematics syllabi. The findings show mismatches in teacher training curricula and disparities in teacher expertise in schools. As a result, the most challenging topics to teach are core to the national examinations, which risks students' poor performance. Despite students' improved performance over time, it is still below average. Teachers' coping mechanisms for these content challenges are inadequate to elevate their competencies. Therefore, students' performance in the subject will continue to be below average unless teacher education curricula are improved to eliminate the variations in the quality of teachers.

The development and frequent review of teacher education curricula must be a top priority in universities to reflect industry requirements (secondary school context). There is a need to develop modules that will be compulsory in all teacher-training programs. The focus of the improved curricula should be to develop a complete and competent teacher who can teach one curriculum rather than having a variety of teachers from different teacher education programmes.

5.0 Conflict of Interest Statement

The authors declare they have no conflict of interest.

6.0 Funding

This research did not receive grants from public, commercial, or not-for-profit funding agencies.

7.0 References

Bar-Tal, S., Chamo, N., Ram, D., Snapir, Z., & Gilat, I. (2020). First steps in a second career: characteristics of the transition to the teaching profession among novice teachers. *European Journal of Teacher Education, 43*(5), 660–675. https://doi.org/10.1080/02619768.2019.1708895

Blömeke, S., Kaiser, G., König, J., & Jentsch, A. (2020). Profiles of mathematics teachers' competence and their relation to instructional quality. *ZDM, 52*(2), 329–342. https://doi.org/10.1007/s11858-020-01128-y

Bussey, T. J., Orgill, M., & Crippen, K. J. (2013). Variation theory: A theory of learning and a useful theoretical framework for chemical education research. *Chem. Educ. Res. Pract., 14*(1), 9–22. https://doi.org/10.1039/C2RP20145C

Cochran-Smith, M., Keefe, E. S., Carney, M. C., Sánchez, J. G., Olivo, M., & Smith, R. J. (2020). Teacher preparation at new graduate schools of education. *Teacher Education Quarterly, 47*(2), 8–37.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.).* SAGE Publication Ltd.

Damşa, C., Langford, M., Uehara, D., & Scherer, R. (2021). Teachers' agency and online education in times of crisis. *Computers in Human Behavior, 121*, 106793. https://doi.org/10.1016/j.chb.2021.106793

Denzin, N. K., & Lincoln, Y. S. (2018). *The SAGE handbook of qualitative research* (N. K., Denzin & Y. S. Lincoln, Eds.). SAGE Publication.

Fischer, C., Foster, B., Mccoy, A., Lawrenz, F., Dede, C., Eisenkraft, A., Fishman, B. J., Frumin, K., & Levy, A. J. (2020). identifying levers related to student performance on high-stakes science exams: Examining school, teaching, teacher, and professional development characteristics. *Teachers College Record: The Voice of Scholarship in Education, 122*(2), 1–64. https://doi.org/10.1177/016146812012200202

Flores, M.A. (2016). Teacher education curriculum. In: Loughran, J., Hamilton, M. (eds) *International handbook of teacher education*. Springer, Singapore. https://doi.org/10.1007/978-981-10-0366-0_5

Gasteiger, H., Bruns, J., Benz, C., Brunner, E., & Sprenger, P. (2020). Mathematical pedagogical content knowledge of early childhood teachers: a standardized

standardized situation-related measurement approach. ZDM, 52(2), 193–205. https://doi.org/10.1007/s11858-019-01103-2

Genc, M., & Erbas, A. K. (2020). Exploring secondary mathematics teachers' conceptions of the barriers to mathematical literacy development. *International Journal for Mathematics Teaching and Learning, 21*(2), 143–173. https://doi.org/10.4256/ijmtl.v21i2.181

Inprasitha, M. (2015). Transforming education through lesson study: Thailand's decade-long journey. In: Cho, S. (eds) *Selected regular lectures from the 12thinternational congress on mathematical education*. Springer, Cham. https://doi.org/10.1007/978-3-319-17187-6_20

Kaiser, G., & König, J. (2019). Competence measurement in (mathematics) teacher education and beyond: Implications for policy. *Higher Education Policy, 32*(4), 597–615. https://doi.org/10.1057/s41307-019-00139-z

Kajoro, P. (2016). Mathematics teacher training in East Africa. In: Halai, A., Tennant, G. (eds) *Mathematics education in East Africa*. SpringerBriefs in Education. Springer, Cham. https://doi.org/10.1007/978-3-319-27258-0_5

Ker, H. W. (2013). Trend analysis on mathematics achievements: A comparative study using TIMSS data. *Universal Journal of Educational Research, 1*(3), 200–203. https://doi.org/10.13189/ujer.2013.010309

Kihwele, J. E., & Mgata, F. (2022). Mathematics teachers' use of WhatsApp groups as a platform for continuous professional development in Tanzania*. African Journal of Teacher Education, 11*(1), 121–142. https://doi.org/10.21083/ajote.v11i1.6541

Kihwele, J. E., &Mkomwa, J. (2023). Promoting students' interest and achievement in mathematics through "King and Queen of Mathematics" initiative. *Journal of Research in Innovative Teaching & Learning, 16*(1), 115–133. https://doi.org/10.1108/JRIT-12-2021-0083

Kihwele, J. E., &Mtandi, R. (2020). Impact of teaching practice on pre-service teachers' pedagogical competencies in Tanzania. *East African Journal of Education and Social Sciences, 1*(1), 101–111. https://doi.org/10.46606/eajess2020v01i01.0011

Kotthoff, H.-G., &Terhart, E. (2013). 'New' solutions to 'old' problems? Recent reforms in teacher education in Germany*. Revista Española de EducaciónComparada, 0*(22), 73. https://doi.org/10.5944/reec.22.2013.9324

Kullberg, A., Runesson Kempe, U., & Marton, F. (2017). What is made possible to learn when using the variation theory of learning in teaching mathematics? *ZDM, 49*(4), 559–569. https://doi.org/10.1007/s11858-017-0858-4

Lauermann, F., & ten Hagen, I. (2021). Do teachers' perceived teaching competence and self-efficacy affect students' academic outcomes? A closer look at student-reported classroom processes and outcomes. *Educational Psychologist, 56*(4), 265–282. https://doi.org/10.1080/00461520.2021.1991355

Nyamwesa, A. M., Magambo, E. F., & Onyango, D. O. (2020). Impact of external quality assurance practices on higher education institutions in Tanzania: A review paper. *East African Journal of Education and Social Sciences, 1*(3), 191–196. https://doi.org/10.46606/eajess2020v01i03.0059

Mahmud, M. S., Maat, S. M., Rosli, R., Sulaiman, N. A., & Mohamed, S. B. (2022). The application of entrepreneurial elements in mathematics teaching: Challenges for primary school mathematics teachers.

Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.753561

Mazana, M. Y., Montero, C. S., &Njotto, L. L. (2023). Exploring mathematics teaching approaches in Tanzanian higher education institutions: Lecturers' perspectives. *International Journal of Research in Undergraduate Mathematics Education*. https://doi.org/10.1007/s40753-023-00212-4

Moh'd, S. S., Uwamahoro, J., Joachim, N., &Orodho, J. A. (2021). Assessing the level of secondary mathematics teachers' pedagogical content knowledge. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(6), em1970. https://doi.org/10.29333/ejmste/10883

Moliner, L., & Alegre, F. (2022). Attitudes, beliefs and knowledge of mathematics teachers regarding peer tutoring. *European Journal of Teacher Education, 45*(1), 93–112. https://doi.org/10.1080/02619768.2020.1803271

Murray, J. (2013). The Factors that influence mathematics achievement at the Berbice Campus. *International Journal of Business and Social Science, 4*(10), 150–164.

National Examination Council of Tanzania. (2022). *Examinations statistics*. NECTA.

OECD. (2016). *PISA 2015 Results in focus*. OECD.

Pryor, J., Akyeampong, K., Westbrook, J., & Lussier, K. (2012). Rethinking teacher preparation and professional development in Africa: an analysis of the curriculum of teacher education in the teaching of early reading and mathematics. *The Curriculum Journal, 23*(4), 409–502. https://doi.org/10.1080/09585176.2012.747725

Qadhi, S., Alkubaisi, H. (2022). Teachers' education in Qatar: Devolution and decentralization. In: Khine, M.S. (eds) *Handbook of research on teacher education*. Springer, Singapore. https://doi.org/10.1007/978-981-19-2400-2_2

Sa'ad, T. U., Adamu, A., & M. Sadiq, A. (2014). The causes of poor performance in mathematics among public senior secondary school students in Azare Metropolis of Bauchi State, Nigeria. *IOSR Journal of Research & Method in Education (IOSRJRME), 4*(6), 32–40. https://doi.org/10.9790/7388-04633240

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research methods for business students (7th ed.)*. Pearson Education Limited.

Singh, L., & Shakir, M. (2019). Teacher education: Issues and concerns in current scenario. *International Journal of Research and Analytical Reviews (IJRAR), 6*(2), 1082–1091.

Tay, E. G., & Kaur, B. (2021). Mathematics teacher education in Singapore. In D. R. Thompson, M. A. Huntley, & C. Suurtamm (Eds.), *International perspectives on mathematics teacher education* (pp. 93–111). Information Age Publishing Inc.

Tazitabong, A. J. (2021). Influence of teacher's competence on students learning in some selected secondary schools inBuea Municipality in the South West Region of Cameroon. *International Journal of Scientific and Management Research, 04*(08), 93–115. https://doi.org/10.37502/IJSMR.2021.4809

Venkat, H.& Adler, J. (2014). Pedagogical content knowledge in mathematics education. In: Lerman, S. (eds.) *Encyclopedia of mathematics education*. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4978-8_123

Wang, H.-H., Charoenmuang, M., Knobloch, N. A., & Tormoehlen, R. L. (2020). Defining interdisciplinary collaboration based on high school teachers' beliefs and practices of STEM integration using a complex designed system. *International Journal of STEM*

Education, 7(1), 3. https://doi.org/10.1186/s40594-019-0201-4

Werler, T. C., & Tahirsylaj, A. (2022). Differences in teacher education programmes and their outcomes across Didaktik and curriculum traditions. *European Journal of Teacher Education, 45*(2), 154–172. https://doi.org/10.1080/02619768.2020.1827388

Wong, S. L., & Wong, S. L. (2019). Relationship between interest and mathematics performance in a technology-enhanced learning context in Malaysia. *Research and Practice in Technology Enhanced Learning, 14*(1), 21. https://doi.org/10.1186/s41039-019-0114-3

Yeh, C. Y. C., Cheng, H. N. H., Chen, Z.-H., Liao, C. C. Y., & Chan, T.-W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning, 14*(1), 5. https://doi.org/10.1186/s41039-019-0100-9

APPENDICES

Appendix 1: Perceived competencies in O-Level mathematics topics among teachers

#	Topic in ordinary level curriculum	U1	U2	#	Topic in ordinary level curriculum	U1	U2
FORM ONE				**FORM THREE**			
1	Numbers	√	√	1	Relations	X	√
2	Fractions	X	√	2	Functions	√	√
3	Decimals and percentages	X	√	4	Statistics	√	√
4	Units	X	X	5	Rates and variations	X	X
5	Approximations	X	√	6	Sequence and series	X	√
6	Geometry	X	X	7	Circles	X	X
7	Algebra	√	√	8	The Earth as a sphere	X	X
8	Numbers II	X	√	9	Accounts	X	X
9	Ratio, profit and loss	X	X				
10	Coordinate Geometry	√	X				
11	Perimeters and Areas	X	√				
	Mastered topics per level	**3 (27.3%)**	**7 (63.3%)**		**Mastered topics per level**	**2 (22.2%)**	**4 (44.4%)**
FORM TWO				**FORM FOUR**			
1	Exponents and radicals	X	X	1	Coordinate geometry	√	X
2	Algebra	√	√	2	Area and perimeter	X	√
3	Quadratic equations	X	X	3	Three-dimensional figures	X	√
4	Logarithms	X	X	4	Probability	√	√
5	Congruence	X	X	5	Trigonometry	√	X
6	Similarity	X	X	6	Vectors	√	√
7	Geometrical transformation	X	X	7	Matrices and transformations	√	√
8	Pythagoras theorem	√	X	8	Linear programming	√	√
9	Trigonometry	√	X				
10	Sets	√	√				
11	Statistics	√	√				
	Mastered topics per level	**5 (45.5%)**	**3 (27.3%)**		**Mastered topics per level**	**6 (75%)**	**6 (75%)**