Center for Open Access in Science ▪ https://www.centerprode.com/ojer.html
Open Journal for Educational Research, 2018, *2*(2), 57-72.
ISSN (Online) 2560-5313 ▪ https://doi.org/10.32591/coas.ojer.0202.01057d

Teacher Knowledge Manifestation of Integrated Science Teachers in Zimbabwe

Diamond Dziva, Maroni Runesu Nyikahadzoyi
University of Bindura, Curriculum Studies, Zimbabwe

Konstantinos Ravanis, Dimitrios Koliopoulos
University of Patras, Greece
Department of Educational Sciences and Early Childhood Education

Received 1 September 2018 ▪ Revised 29 October 2018 ▪ Accepted 2018

Abstract

This study explored the teacher knowledge manifestation of Integrated Science (IS) teachers who have specialised in Chemistry, Biology or Physics during their pre-service teacher education. 60 experienced Integrated Science teachers responded to an 'Integrated Science Teacher Knowledge' questionnaire which embraced different dimensions of teacher knowledge. The results of the study indicate that the IS teachers have a common set of knowledge, skills, and dispositions that are, in their professional opinion, needed and in some instances, would enable them to teach IS. The research participants had considerable knowledge as well as clear views about what it meant for them to be IS teachers. It however should be noted that there was a marked variance in the perception of the three cohorts of teachers towards teaching through Practical Work, importance of pre-service teacher education specialisation towards teaching IS and knowledge of students' culture. This study provides contextual inputs to effective IS teacher education re-alignment informed by the IS teacher practitioners, those with the craft knowledge of the contextual environment of the IS classrooms.

Keywords: teacher knowledge, integrated science, Zimbabwean educational system.

1. Introduction

This research is framed under the theoretical perspective of teacher knowledge. There is an on-going discourse on exploring teacher knowledge in General Education and Science Education fields (Elbaz, 1983; Shulman, 1987; Grossman, 1990; Carlsen, 1999; Lederman, 2006; Chapman, 2013; Goodwin & Kosnik, 2013; Adoniou, 2015; Mouza et al., 2017; Slavit & Lesseig, 2017). The nature of teacher knowledge debates often borders on whether teacher knowledge is situated within contexts or it is propositional in nature (Calderhead, 1996). Teacher knowledge research is essential as it has a direct bearing on student success (Coleman, et al., 1966; Ferguson, 1991; Flippo, 2001; Ingersoll, 2002; Reutzel & Cooter, 2012). Teacher knowledge is by definition, embedded in the personal context of the teachers, where all kinds of domain-related, teacher-related and pupil-related and the intermingling of these circumstances play a role. Verloop, Driel and Meijer (2001) stress that it is logical to direct the search for shared teacher knowledge on

© **Authors**. Terms and conditions of Creative Commons Attribution 4.0 International (CC BY 4.0) apply.
Correspondence: Konstantinos Ravanis, University of Patra .... E-mail: ravanis@upatras.gr.

groups of teachers that are in similar situations with respect to variables such as subject matter, level of education, and age group of students.

This research interrogates the teacher knowledge manifestation of Zimbabwean Integrated Science teachers who have specialised in Chemistry, Biology or Physics during their pre-service teacher education. These teachers are likely to experience out-of-field teaching phenomenon when teaching certain topics of Integrated Science Ordinary Level school subject. Out-of-field teaching has been described as "education's dirty little secret". According to du Plessis (2017), out-of-field teaching is not an aberration, and it is not restricted to only a few subjects-for example, to the STEM-subject areas of Science, Technology, Engineering and Mathematics – but has implications for all subject areas and year level.

Science education in Zimbabwe at Forms 3 and 4 (15-16 -year olds) also referred to as Ordinary Level (O-Level) exists in a number of subject syllabi ranging from Chemistry, Biology, Physics, Human and Social Biology to Integrated Science. The Integrated Science subject is however the most common Science subject in Zimbabwean schools with for instance 151,717 candidates having set for O-Level terminal examinations in the year 2016 as compared to Biology's 23,138, Physics' 6,767 and Chemistry's 6,842 candidates (Zimbabwe School Examinations Council, 2016). Student have not been performing very well in terminal Integrated Science in Zimbabwe School Examinations Council (ZIMSEC) examinations at Ordinary Level. An analysis of November Ordinary Level examination results confirms that the performance of students in IS was general low as compared to other science subjects, for instance in year 2014 IS pass rate was 21.9% and in 2015 it was 31.52% (Zimbabwe School Examinations Council, 2016). Comparing the 2016 pass rate with other Science subjects, whilst IS was 39.58%, Physics was 61.18%, Biology was 57.07% and that of Chemistry was 77%. According to Makwati (2000: 1), "teachers are the single, most important component in the Zimbabwean education system. They are also the only measure parents, students, and administrators have for evaluating the effectiveness of the school system. Teachers have been institutionalised in the education system and remain the focal point of all curricular and classroom organisation" and hence the focus of this study on teacher knowledge.

The Integrated Science syllabus is divided into 5 compulsory components, i.e. Science in Agriculture, Science in Industry, Science in Energy Uses, Science in Structures and Mechanical Systems and Science in the Community. Applications of science and technology to agriculture, environmental, and socio-economic fields are embedded in the syllabus as an extension of subject concepts and skills. These concepts are intended to be imparted to students through an investigative and practical approach. In Zimbabwe there is no specific pre-service Integrated Science teacher education programme. Most prospective teachers specialise in specific science disciplines like Chemistry, Biology or Physics. With this context in mind, this study is therefore guided and limited by a central question: How do teachers who specialised in Chemistry, Biology or Physics describe secondary school Integrated Science teaching?

2. Research methodology

Sixty Integrated Science teachers were selected through snowball sampling and surveyed. These 60 research participants were distributed across 3 equal cohorts according to their specialisation areas of study at pre-service teacher education (i.e., Chemistry, Biology and Physics education). A 5-point Likert Scale Integrated Science Teacher Knowledge questionnaire was developed based on an extensive review of the literature that provided the most important aspects to be evaluated, which were later reflected in the questionnaire items 1 to 15. The questionnaire items embraced the different dimensions of teacher knowledge (Elbaz, 1983; Shulman, 1986; Grossman, 1990; Carlsen, 1999; Mouza et al., 2017). They closely matched the theoretical framework about different types of teacher knowledge through encompassing the practical and propositional knowledge that IS teachers expressed (Elbaz, 1983; Shulman, 1986).

The initial designed instrument had 53 items pieced together from several existing instruments which measure teacher knowledge. After the questionnaire had been developed, it was submitted to a panel of three university professors who acted as judges. They were asked to react to the questionnaire and suggest any necessary revisions for the items. They content validated the instrument to verify that the items were appropriate and were likely to yield accurate responses. The questionnaire items were derived from Teacher Knowledge Domains: General Pedagogical Knowledge – items 1, 5, 7, 9, 10; Subject Matter Knowledge – item 14; Pedagogical Content Knowledge – items 2, 3, 4, 8, 11, 12, 15; and Knowledge about the Specific Context – items 6, 13. These knowledge domains were derived from the studies of Elbaz (1983), Shulman (1986; 1987), Grossman (1990) and Carlsen (1999). The questionnaire was physically distributed to the 60 Integrated Science teachers in four provinces of varying size, location, and population in Zimbabwe. Analysis of the questionnaire responses was electronically done on IBM SPSS (Statistical Package for Social Science) version 24 software.

3. Research findings and discussion

Table 1 indicate the response frequency to the fifteen questionnaire items. As indicated on Table 1 the response rate to the Likert scale items was high. However, three respondents each, making up 5% per questionnaire item 5 and 15 did not attempt to respond to these. These high response rate might be pointing to the high drive of the participants to partake in this research and as well, the issues being interrogated by this research resonated with the concerns that the Integrated Science (IS) teachers have as they practice their profession.

Table 1

Summary of the questionnaire items frequency

	Strongly Agree		Agree		Neither Agree nor Disagree		Disagree		Strongly Disagree		
Code	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**	**Valid N**
1.	15	25.0	29	48.3	8	13.3	5	8.3	2	3.3	59
2.	29	48.3	23	38.3	2	3.3	6	10.0			60
3.	32	53.3	19	31.7			6	10.0	1	1.7	58
4.	22	36.7	28	46.7	5	8.3	5	8.3			60
5.	13	21.7	16	26.7	6	10.0	15	25	7	11.7	57
6.	17	28.3	16	26.7	3	5.0	16	26.7	7	11.7	59
7.	8	13.3	23	38.3	7	11.7	14	23.3	7	11.7	59
8.	8	13.3	15	25.0	6	10.0	24	40.0	6	10.0	59
9.	6	10.0	9	15.0	7	11.7	27	45.0	10	16.7	59
10.	42	70.0	14	23.3	2	3.3					58
11.	4	6.7	9	15.0	18	30.0	24	40.0	5	8.3	60
12.	3	5.0	3	5.0	6	10.0	29	48.3	18	30.0	59
13.	17	28.3	22	36.7	5	8.3	16	26.7			60
14.	4	6.7	15	25.0	7	11.7	24	40.0	10	16.7	60
15.	7	11.7	21	35.0	9	15.0	13	21.7	7	11.7	57

Code

1. Need of student culture knowledge
2. Importance of Knowledge of History of Science in teaching
3. Teaching Practicals is as important as teaching Theory
4. Practical Work enhance student learning
5. Teaching Integrated Science is different from teaching other science subjects
6. Specialising in a science discipline is important in teaching IS
7. I could be a better teacher if I had not specialised in one science discipline
8. When teaching a particular section of IS, I divert and teach another aspect of IS if that aspect captures student interest at that time
9. The rate of student learning does not impact my teaching of IS
10. Audio and visual aids are important in facilitating student learning of IS
11. IS teaching should mostly be done outdoors
12. I have not been trained in the use of IT as a science teaching aid
13. The subject matter/content taught at college is enough for one to teach IS
14. Upon being employed, I had to start reading hard in order to be able to teach those topics in IS divorced from my area of specialisation
15. IS teaching should mostly be conducted in-doors i.e. in laboratories or classrooms

3.1 *Need for student culture knowledge*

On being asked on need for student culture knowledge when teaching IS, 85% of IS teachers who specialised in Biology Education indicated that teaching IS requires as a prerequisite

some knowledge of students' culture. This was at par at 85% with IS teachers who specialised in Chemistry education at college whilst only 50% of IS teachers who specialised in Physics Education agreed that teaching IS requires knowledge of students' culture (Figure 1).

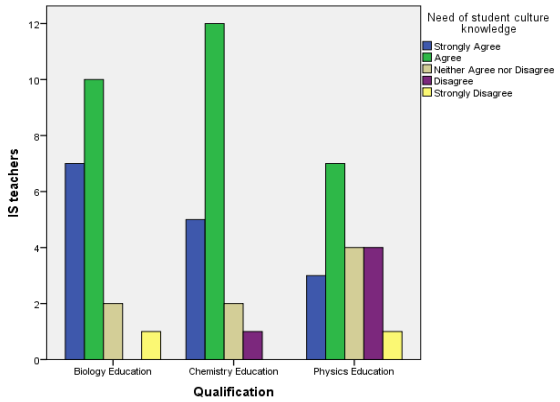

Figure 1. Crosstabulation of IS teacher qualification against need of knowledge of students' culture

Knowledge about students' cultural background and its influence on students' misconception on certain scientific concepts together with the ability of a teacher to manage these misconceptions lie at the heart of what effective science teachers do and are indeed important aspects of pedagogical knowledge (Shulman, 1986, 1987). The research participants were generally in concurrence across the cohorts that students' culture was essential for learning IS, this disclosure is consistent with the research findings of Dziva, Mpofu, & Kusure (2011) although the research participants in Dziva et al. (2011) study placed the students' cultural knowledge on a low rung of importance.

3.2 *Importance of knowledge of History of Science in teaching*

On being asked to indicate the degree of agreement to questionnaire item statement 2 which read, "It is important for IS teachers to know the history of science", the IS teachers' response is presented on Figure 2 cross tabulated against their area of teaching specialisation.

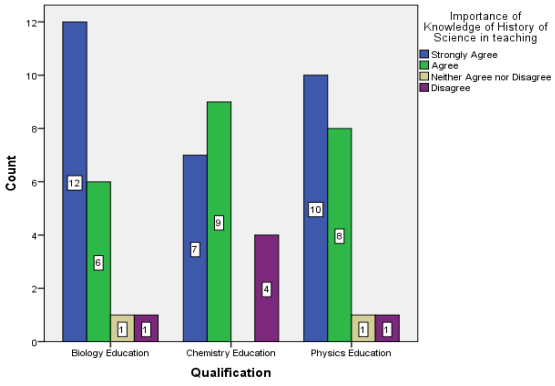

Figure 2. Crosstabulation of Qualification and Importance of Knowledge of History of Science in teaching

The IS teachers who specialised in Biology and Physics agreed to this statement matching at eighteen participants per cohort. Although sixteen participants from the Chemistry cohort agreed to the statement, four participants from this cohort disagreed to the said statement

as compared to one participant apiece for the Physics and Biology cohort. By and large about 87% of the participating IS teachers agreed with the importance of history of science in student learning. Literature has it that the history of science proffers vivid, concrete case studies that demonstrates the nature of scientific reasoning (Matthew, 1994; Pitt, 1990) and hence maybe that is the reason why the majority of IS teachers recognise its importance. The history of science unravels the Nature of Science as well as providing examples of Pedagogical Content Knowledge which the IS teachers hold in the form of syntactic knowledge which are the agreements, norms. paradigms, and ways of establishing new knowledge that scientists in their respective specialisations hold as currently acceptable (Gess-Newsome, 1999). Many science educators treasure the history of science as it uncovers the scientific process, instead of focusing solely on final products and possesses a great potential for a multifaceted improvement of the learning process and its results (Galili & Hazan, 2002).

3.3 *Teaching through Practical Work is as important as teaching Theory*

Of the 58 Integrated Science teachers who responded to Item 3, 55.2% strongly agreed that teaching through Practical Work was as important as teaching theory, 32.8% agreed whilst 10.3% disagreed and 1.7% strongly disagreed. Fifty-two Integrated Science teachers which is about 90% of the respondents, agreed to strongly agreed that teaching IS through practical work is as important as teaching it theoretical, whilst 6 (10%) disagreed to strongly disagreed to this.

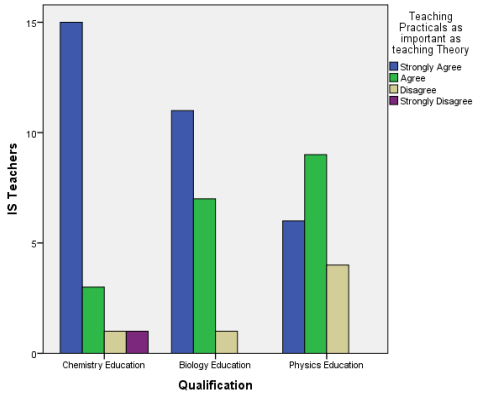

Figure 3. Crosstabulation of IS teacher qualification against their perception on teaching through practical work as important as teaching theoretical

Although the IS teachers generally strongly agreed with the statement that: "Teaching through Practical Work is as important as teaching theory in IS"; the level of strongly agreeing was more from the Chemistry education specialisation cohort than the other two cohorts (Figure 3). On the other hand, the Physics education specialisation cohort had more teachers disagreeing to the questionnaire statement item 3 as compared to the other two cohorts.

3.4 *Practical Work enhance student learning*

84.4% of IS teachers agreed to strongly agreed on the importance of Practical Work in enhancing student learning (Figure 4) as compared to 8.3% who disagreed. From the results of the survey it emerged that teachers recognise the importance of Practical Work in Integrated Science. Literature allude to the fact that general there is no remarkable divergence about the importance of Practical Work in school science (Kapenda et al., 2002) the main issues raised are on whether any such Practical Work endeavour genuinely supports learning and teaching.

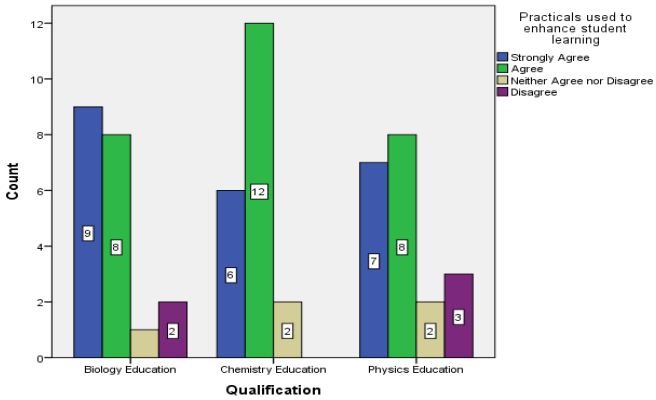

Figure 4. Crosstabulation of Qualification and Importance of Practical Work in enhancing learning

3.5 *Teaching Integrated Science is different from teaching other science subjects*

About 48% of the research participants indicated that teaching IS is different from teaching other subjects whilst 36.7% viewed the teaching of IS as being similar to teaching any other science subject (Figure 5). The 36.7% IS teachers are missing the point on what constitute IS which according to Harrel (2010) is an approach to learning and teaching from an assortment of world-views, strategies, and resources; and the taking advantage of real-life situations for problem solving and critical thinking in the classroom. It therefore should be taught in a different way as compared to other science subjects.

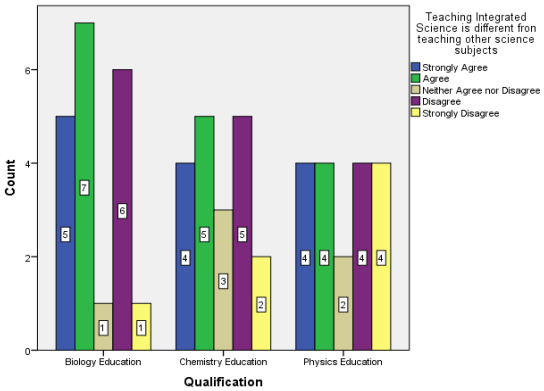

Figure 5. Crosstabulation of Qualification and uniqueness of teaching IS

3.6 *Specialising in a science discipline is important in teaching IS*

Figure 6 shows the crosstabulation of IS teacher qualification against their views on the need for specialising in a particular science discipline in order to teach IS. 55% of the research participants agreed to strongly agreeing that specialising during pre-service teacher education was important as a preparation for teaching IS, 38.4% disagreed whilst the rest were undecided. It can be observed from Figure 6 that the count of IS teachers who agreed were higher for the Biology cohort as compared to the other cohorts. This questionnaire item did not however interrogate if the IS teachers thought whether their subject area specialisation was the one which was need or not for IS teaching. The questionnaire item 7 interrogated this.

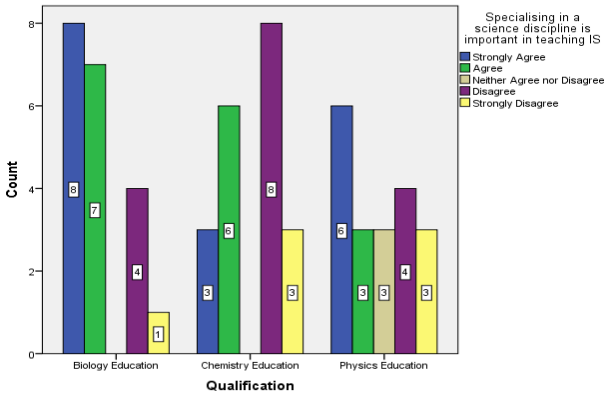

Figure 6. Crosstabulation of IS teacher qualification against the need for specialising in a particular science discipline in order to teach IS

Researches on teaching science topics within and outside areas of specialism reveal important differences in the quality of preparation and delivery of science lessons (Harrell, 2010; du Plessis, 2017; Nixon & Luft, 2015). IS teachers might find themselves feeling 'out-of-field' when found teaching those concepts which they are not specialised in, however, because of the nature of IS in Zimbabwe which has about 75% Biology content (ZIMSEC, 2010) the IS teachers might feel that those who specialise in Biological discipline are better-off.

3.7 *Need for not specialised in one science discipline at pre-service teacher education level*

70% of IS teachers who specialised in Chemistry Education viewed the importance of not specialising in a single science discipline as they agreed to questionnaire item number 7 whilst 60% of IS teachers who specialised in Biology Education agreed with Item 7. For those who specialised in Physics education only 25% of IS teachers reported as agreeing to being better teachers if they had not only specialised in Physics Education. 11 of those teachers who specialised in Physics education at college were more inclined to the view that specialising in Physics education was enough for one to be a better IS teacher.

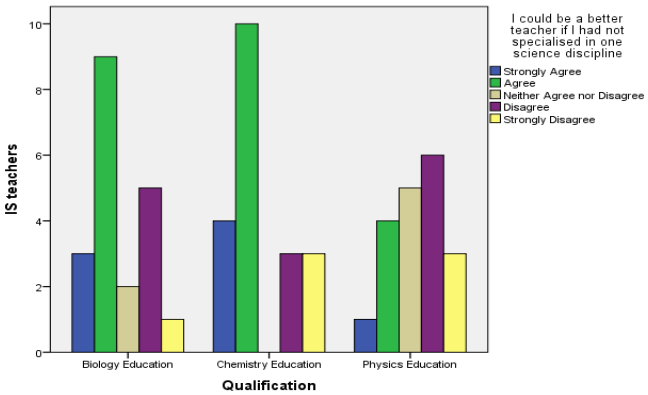

Figure 7. Crosstabulation of IS teacher qualification against effect of specialisation on IS teaching

It is evident that teachers who specialised in Physics education most times are teaching IS concepts out-of-field. However even when they are aware of this it is evident that they identify themselves with their area of specialisation and are satisfied that it is good enough preparation for them to teach IS (Figure 7).

3.8 *Divert to teach aspects of IS if that aspect captures student interest during a lesson*

On being asked on whether they concurred that they would divert and teach another aspect of IS if that aspect captures student interest at that time when teaching a particular section of IS, 38.3% of the research participants agreed 50% disagreed whilst 10% neither agreed nor disagreed and IS teacher did not respond to the item (Figure 8). The reason why 50% of the IS teacher participants disagree with the statement item might be that these teachers remember instances of their teaching outside subject specialism in which situation, according to Mizzi (2013), there is a tendency to be rigid, less confident in their teaching, following a textbook structure quite closely and tending to ask recall questions.

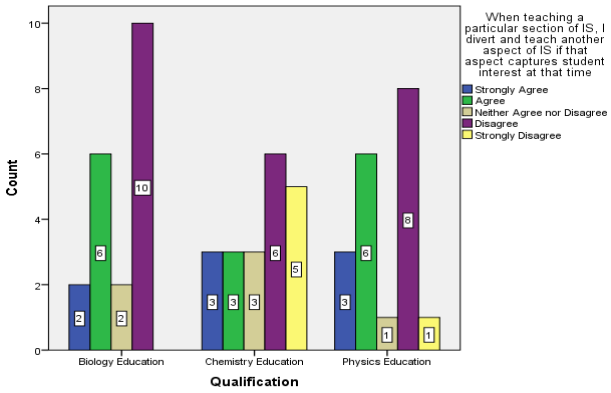

Figure 8. Crosstabulation of IS teacher qualification against teaching that captures student interest

3.9 *Influence of rate of student learning on teaching of IS*

The majority of the IS teachers disagreed to the questionnaire item statement which stated that the rate of student learning did not impact their teaching of IS.

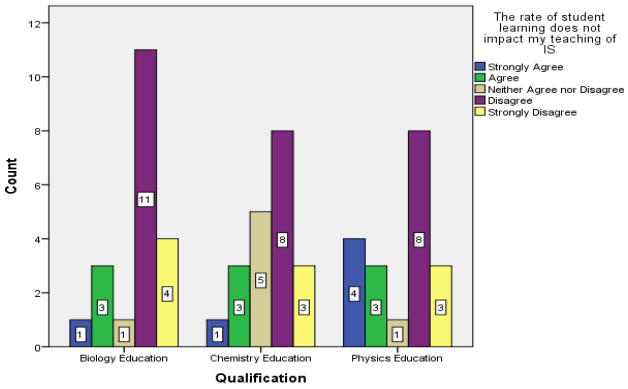

Figure 9. Crosstabulation of IS teacher qualification against impact of rate student learning on IS teaching

61.7% of the participating IS teachers disagreed to strongly disagree, 25% agreed to strongly agreed, 11.7 % neither agreed nor disagreed and one teacher did not respond to the question. Across the 3 cohorts the IS teachers recognised the need to pace teaching with rate of student learning and in so doing the teachers acknowledge the "knowledge of students" and "learner characteristics" as propounded by Shulman (1987).

3.10 *Importance of audio and visual aids in facilitating student learning of IS*

93.3% of the research participants agreed to strongly disagreeing that audio and visual aids facilitated student learning of IS whilst 3.3% neither disagreed nor agreed, two participants did not however respond to the questionnaire item (Figure 10).

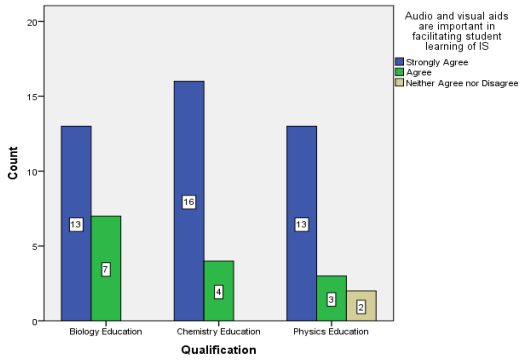

Figure 10. Crosstabulation of IS teacher qualification against importance of audio and visual aids in facilitating student learning

The level of concurrence to the importance of audio-visual aids in facilitating learning cut across all the three cohorts. The audio and visual aids have been identified by Grossman (1990) as the 3rd PCK knowledge of which teachers are expected to know the curricular materials available to enact the curriculum.

3.11 *Teaching IS outdoors*

Item 11 of the questionnaire asked on whether IS teachers agreed or not with the statement: "Integrated Science teaching should mostly be done outdoors". 21.7% agreed, 30% neither disagreed nor agreed whilst a substantial number of 48.3% disagreed to strongly disagree across the three cohorts (Figure 11).

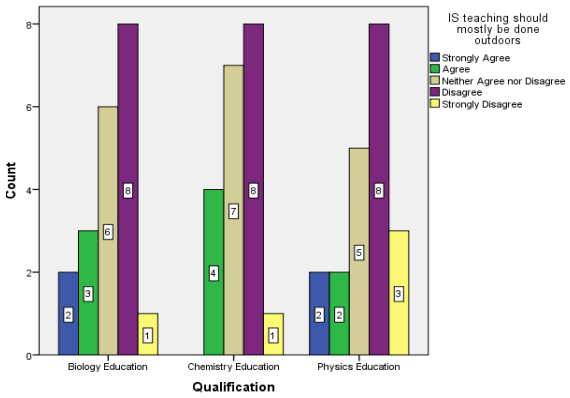

Figure 11. Crosstabulation of IS teacher qualification against need of teaching of IS through outdoors activities

Despite the fact that the IS syllabi document recommend that teachers should take advantage of out-doors to facilitate learning through for example field observations some teachers still view this approach as undesirable (ZIMSEC, 2010).

3.12 *Training to use IT as a science teaching aid*

78.3% of the research participants indicated that they were well trained in the use of IT to aid IS teaching whilst 10% said the contrary and another 10% neither agreed nor disagreed. One teacher however did not respond to the questionnaire item.

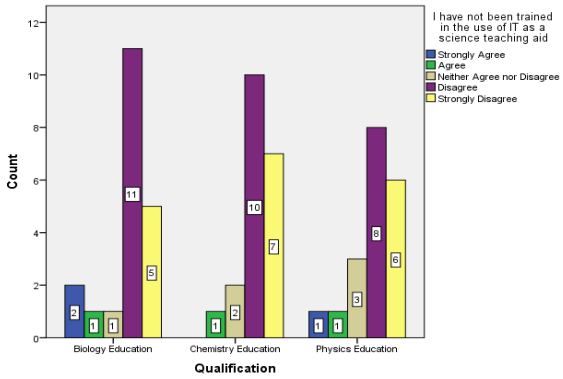

Figure 12. Crosstabulation of IS teacher qualification against training in the use of IT to aid IS teaching

The response to this item is consistent to the response given to questionnaire item 10 where about 93% of the respondents indicated that audio and visual aids facilitate the learning of IS. Nyikahadzoyi (2013: 5) also acknowledged the need for teachers be holders of IT knowledge which he referred to as technological knowledge for the purpose of teaching when he referred to this knowledge as the knowledge of "advanced digital technologies – knowledge of operating systems, computer hardware, ability to use standard sets of software tools such as word processors, spread sheets, browsers, and e-mail".

3.13 *Adequacy of the subject matter/content taught at college to teach IS*

75% of the IS teacher participants felt that the subject matter they were taught at college was adequate for enabling them to teach IS. 8.3% of the teachers were not sure whilst 26.7% felt that the content knowledge which they were taught was not adequate for IS teaching (Figure 13).

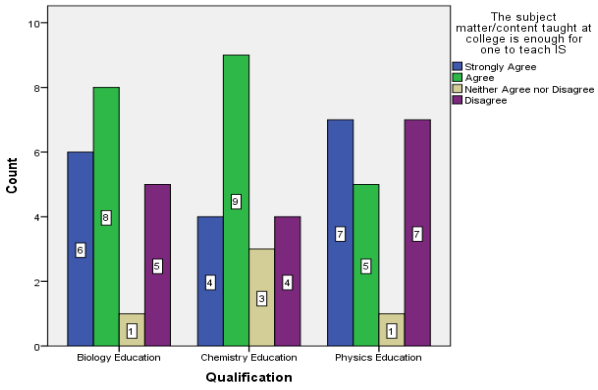

Figure 13. Crosstabulation of IS teacher qualification against adequacy of subject matter/content taught at college for the purpose of teaching IS

Whilst the majority of the research participants viewed subject matter they were taught at college as adequate for IS teaching albiet IS being multidisciplinary and them specialising in one science discipline, Shulman (1986) and Spear-Swerling and Cheesman (2012: 1692) warns that inadequate Content Knowledge by the teacher leads to constricted and

regressionist pedagogies as teachers resort to replicating own past experiences which may result in teachers providing "inadvertently confusing instruction" to students especial in those concepts where they experience out-of-field phenomenon (Nixon & Luft, 2015).

3.14 *IS Teaching experiences upon joining the teaching profession*

31.7% of the respondents across the cohorts indicated that they were ill-prepared Content-wise to teach IS when they joined the teaching profession from college whilst 56.7% said that they were well prepared to teach IS upon assumption of teaching duty from college, however, 8.3% of the research participants were neither in agreement nor disagreement that upon being employed they had to start reading hard in order to be able to teach those topics in IS divorced from their area of specialisation (Figure 14).

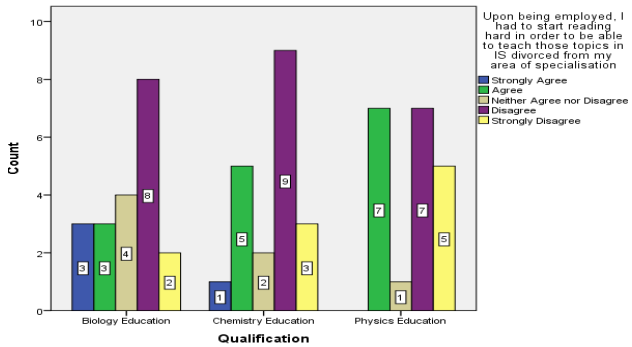

Figure 14. Crosstabulation of IS teacher qualification against content knowledge taught at college versus actual teaching situation

Although the IS teachers acknowledge that there are some content topics in IS which lie outside their area of specialisation more than half of the participants still felt that they were adequately prepared to teach IS upon graduation. This might be due to the fact that most of these participants had learnt IS as a subject at secondary school level and hence the content was not actual new to them but might still however be lacking PCK (Shulman, 1987).

3.15 *IS teaching should mostly be conducted in-doors*

Item 15 of the questionnaire asked the research participants if they agreed or not on whether IS teaching should mostly be conducted in-doors, i.e. in laboratories or classrooms. 36.7% of the participating IS teachers agreed to the teaching of IS indoors whilst 15% could neither agreed nor disagreed and 33.4% disagreed. Three research participants chose not to respond to the questionnaire item.

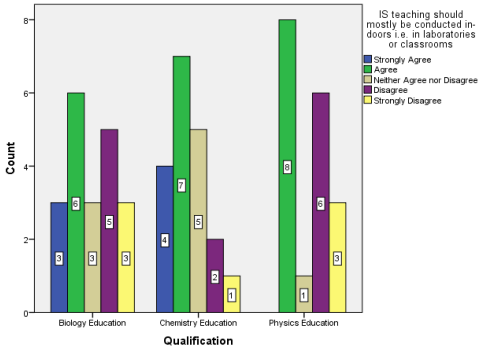

Figure 15. Crosstabulation of IS teacher qualification against teaching of IS in-doors

On comparing the teachers' responses of questionnaire items 11 and 15 it appears as if more of the research participants preferred teaching IS indoors (36.7%) than outdoors (21.7) despite the fact that the teachers should take advantage of out-doors to facilitate learning through for example field observations (ZIMSEC, 2010).

3.16 *Statistical significance*

The IBM SPSS Statistics 24 was used to perform a Kruskal-Wallis test on the Likert-scaled items. The independent variable, or categorical variable, was the qualification (subject specialisation) group to which the Integrated Science teacher belonged. The dependent variables were fifteen Likert-scale ordinal data statements. The analysis was based on the following hypotheses:

H_0: The three groups have the same distribution of scores.

H_A: At least two of the groups will contain a statistically significant difference in the distribution of scores.

Out of the fifteen Likert-scale statements on the questionnaire, one statement (item 3) resulted in a statistically significant difference between groups as noted by the Kruskal-Wallis score, where $p<0.05$ (Table 1). A pairwise comparison post-hoc tests on this item with statistically significant differences was carried out to determine which two groups differed significantly in their responses since a Kruskal-Wallis score does not indicate between which two groups the differences occur. Items 1, 2 and 4-15 were not statistically significant. However, items 1 and 7 did show marginal significance at $p=0.051$ and 0.084, respectively and hence considered as *just conditions*.

Table 2. Test statistics a, b

Dependent Variables														
1. Need for culture in IS teaching	2. Importance of History of Science	3. Practicals and Theory	4. Practicals	5. Uniqueness of Integrated Science	6. Specialising at college	7. Not specialising at college	8. Not focusing on one task	9. Rate of Student Learning	10. Aids	11. Teaching IS out-doors	12. IT training	13. Subject matter acquired at College	14. Preparation for Teaching	15. Teaching IS in-doors
5.850	2.885	6.792	.751	.917	4.406	4.917	1.517	1.522	1.087	.677	.703	.166	.923	3.643
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
.054	.236	.034	.687	.632	.110	.086	.468	.467	.581	.713	.704	.920	.630	.162
.051	.241	.032	.688	.637	.110	.084	.474	.474	.568	.719	.706	.921	.635	.163
.000	.002	.000	.001	.000	.000	.000	.000	.000	.007	.001	.001	.001	.001	.000
a. Kruskal Wallis Test														
b. Grouping Variable: Qualification														

Item 3 stated: "Teaching through practical work is as important as teaching theory in IS". This item showed a significant difference in views regarding the statement between teachers who have specialised in chemistry education and those who have specialised in physics education

during their teacher education programmes. The difference maintained statistical significance following the Bonferroni correction, where *adj.p*=0.033. Integrated Science teachers who specialised in Chemistry education were much more likely to accept as true that teaching through Practical Work is as important as teaching theory in Integrated Science than those who specialised in Physics Education.

Table 3. Questionnaire item 3's Pairwise comparison of teachers' qualification

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
Chemistry Education-Physics Education	-12.279	4.827	-2.544	.011	.033
Biology Education-Physics Education	-8.684	4.888	-1777	.076	.227
Chemistry Education-Biology Education	3.595	4.827	.745	.456	1.000

Each row tested the null hypothesis that the Sample 1 and Sample 2 distributions were the same. Asymptotic significances (2-sided tests) are displayed. The significance level was .05. Significance values were adjusted by the Bonferroni correction for multiple tests. Although the IS teachers generally strongly agreed with the statement that: "Teaching through practical work is as important as teaching theory in IS"; the level of strongly agreeing was more from the Chemistry education specialisation cohort than the other two cohorts. Whilst about 88% of the respondents agreed to item 3's assertion, about 12% disagreed to this. The IS syllabus document however demands, "practical and investigative approach must be adopted in teaching this syllabus" (ZIMSEC, 2010: 2). Despite the IS teachers resonating with the importance of practical work in teaching IS and being aware of the demands of the IS syllabus document, those from the Physics education specialisation cohort, however, had more teachers disagreeing to the questionnaire statement item number three as compared to the other two cohorts. This sentinel position of teachers from the Physics specialism is in line with the findings of Hashweh (1987) and Nixon and Luft (2015) that if teachers' Content Knowledge is low, it directly influences the way they teach, often times they find themselves comfortable with sticking to the script, employing more teacher centred approaches and the resultant is the accompanied reduced teaching effectiveness as a result of limited content knowledge (Hobbs, 2013). It should be noted that this study is however, not implying that holding a degree qualification with requisite Content Knowledge makes teachers proficient, but, holding a teaching qualification in the "content area serves as a readily available minimum requirement" (Nixon & Luft, 2015: 76). Topic-knowledgeable teachers are often-times more likely to diverge from textbook accounts and demand synthesis from their students and engage in practical activities (Hashweh, 1987). The teachers from the Physics education cohort seem to be less exposed to biology concepts and to some extent chemistry concepts and these are the major concepts which make-up the Integrated Science curriculum at Ordinary Level in Zimbabwe (ZIMSEC, 2010).

4. Conclusion

The results of the study indicate that the IS teachers have a common set of knowledge, skills, and dispositions that are, in their professional opinion, needed and in some instances, would enable them to teach IS. The research participants had considerable knowledge as well as clear views about what it meant for them to be IS teachers.

The research participants were generally in concurrence across the cohorts that students' culture was essential for learning IS. Although almost half of the research participants indicated that teaching IS is different from teaching other subjects, a significant 36.7% viewed the teaching of IS as being similar to teaching any other science subject thus, failing to acknowledge

that each content knowledge has a unique approach to teaching it. The majority of IS teachers who specialised in Chemistry Education and Biology Education acknowledged the importance of not specialising in a single science discipline whilst the majority of IS teachers from the Physics Education cohort disagreed. IS teachers who specialised in Physics education identify themselves with their area of specialisation and were satisfied that it was a good enough preparation for them to teach IS. Across the 3 cohorts the IS teachers general recognised the need to pace teaching with rate of student learning. The was a high level of concurrence across the 3 cohorts on the importance of audio-visual aids in facilitating learning.

Although the IS teachers acknowledged that there were some content topics in IS which lie outside their area of specialisation more than half of the participants still felt that they were adequately prepared to teach IS upon graduation.

The majority of the participating IS teachers agreed to the importance of history of science in student learning. The IS teachers generally strongly agreed with the statement that: "Teaching through practical work is as important as teaching theory in IS"; the level of strongly agreeing, however, was more from the Chemistry education specialisation cohort than the other two cohorts. Integrated Science teachers who specialised in Chemistry education were much more likely to accept as true that teaching Integrated Science through Practical Work was as important as teaching theory than those who specialised in Physics Education. From the results of the survey it emerged that the research participants recognised the importance of Practical Work in Integrated Science. About half of the IS teacher participants indicated that they will not divert to teach aspects of IS if that aspect captures student interest during a lesson. This tendency to be rigid, less confident in their teaching, following a textbook structure quite closely and tending to ask recall questions is often evidenced in instances of teaching outside subject area specialism. The research participants preferred teaching IS indoors (36.7%) than outdoors (21.7) despite them being encouraged to take advantage of out-doors to facilitate learning. The majority of the research participants indicated that they were well trained in the use of IT to aid IS teaching.

Slightly above half of the research participants agreed to strongly agreeing that specialising during pre-service teacher education was important as a preparation for teaching IS. The IS teacher participants felt that the subject matter they were taught at college was adequate for enabling them to teach IS albiet IS being multidisciplinary and them specialising in one science discipline.

This study provides contextual inputs to effective IS teacher education re-alignment informed by the IS teacher practitioners, those with the craft knowledge of the contextual environment of the IS classrooms. Ultimately, with the findings of this study, a tool for recruiting and developing teachers who can effectively teach IS can be developed.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public commercial, or not-for-profit sectors.

The author declares no competing interests.

References

Adoniou, M. (2015). Teacher knowledge: A complex tapestry. *Asia-Pacific Journal of Teacher Education, 43*(2), 99-116. https://doi.org/10.1080/1359866X.2014.932330

Carlsen, W. S. (1999). Domains of teacher knowledge. In: J. Gess-Newsome, & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (Vol. 6, pp. 133–146). Boston, MA: Kluwer Academic Publishers.

Chapman, O. (2013). Investigating teachers' knowledge for teaching mathematics. *Journal of Mathematics Teacher Education, 16*, 237–243. https://doi.org/10.1007/s10857-013-9247-2

Childs, A., & McNicholl, J. (2007). Science teachers teaching outside of subject specialism: Challenges, strategies adopted and implications for initial teacher education. *Teacher Development, 11*(1), 1-20.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F., . . . et.al. (1966). *Equality of educational opportunity.* Washington: U.S. Government Printing Office.

du Plessis, A. E. (2017). *Out of field teaching practices. What educational leaders need to know*. Rotterdam: Sense Publishers.

du Plessis, A. E. (2017). *Out-of-field teaching practices what educational leaders need to know*. Rotterdam: Sense Publishers.

Dziva, D., Mpofu, V., & Kusure, L. P. (2011). Teachers' conceptions of Indigenous Knowledge in Science Curriculum in the context of Mberengwa District, Zimbabwe. *African Journal of Education and Technology*, *1*(3), 88-102.

Elbaz, F. (1983). *Teacher thinking: A study of practical knowledge*. London: Croom Helm.

Ferguson, R. F. (1991). Paying for public education: New evidence on how and why money matters. *Harvard Journal on Legislation*, *28*, 465-498.

Flippo, R. F. (2001). *Reading researchers in search of common ground*. Newark, DE: International Reading Association.

Galili, I., & Hazan, A. (2002). The influence of a historically oriented course on the content knowledge of students in optics. In: H. Behrendt, H. Dahncke, R. Duit, W. Gräber, M. Komorek, A. Kross & P. Reiska (Eds.), *Research in science education – Past, present, and future* (pp. 247-251). New York: Kluwer Academic Publishers.

Gess-Newsome, J. (1999). Secondary teachers' knowledge and beliefs about subject matter and their impact on instruction. In: J. Gess-Newsome, & N. Leaderman (Eds.), *Examining pedagogical content knowledge* (pp. 51-94). Dordrecht: Kluwer Academic Publishers.

Goodwin, A. L., & Kosnik, C. (2013). Quality teacher educators = quality teachers? Conceptualizing essential domains of knowledge for those who teach teachers. *Teacher Development, 17*(3), 334-346.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education.* New York: Teacher College, Columbia University.

Harrell, P. E. (2010, Spring). Teaching an integrated science curriculum: Linking teacher knowledge and teaching assignments. *Issues in Teacher Education, 19*(1), 145-165.

Hashweh, M. Z. (1987). Effects of subject-matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education, 3*(2), 109-120.

Hobbs, L. (2013). Teaching "out-of-field" as a boundary-crossing event: Factors shaping teacher identity. *Int J Sci Math Educ, 11*(2), 271-297.

Ingersoll, R. M. (2002). *Measuring out-of-field teaching*. Graduate School of Education, University of Pennsylvania, Philadelphia, PA: Unpublished manuscript.

Kapenda, H. M., Kandjeo-Marenga, H. M., Kasandra, C. D., & Lubben, F. (2002). Characteristics of practical work in science classrooms in Namibia. *Research in Science & Technological Education*, 53-65.

Lederman, N. G. (2006). Syntax of nature of science within inquiry and science instruction. In: B. Flick, & N. G. Lederman (Eds.), *Scientific inquiry and the nature of science: Implications for teaching* (pp. 301-317). Dordrecht: Springer.

Makwati, G. J. (2000). *Education for all the year 2000 assessment: Republic of Zimbabwe*. Harare: Ministry of Education, Sport and Culture.

Matthew, M. R. (1994). *Science teaching: The role of history and philosophy of science*. New York: Routledge.

Mouza, C., Nandakumar, R., Ozden, S. Y., & Karchmer-Klein, R. (2017). A longitudinal examination of preservice teachers' technological pedagogical content knowledge in the context of undergraduate teacher education. *Action in Teacher Education*, 1-20. https://doi.org/10.1080/01626620.2016.1248301

Nixon, R. S., & Luft, J. A. (2015). Teaching chemistry with a biology degree: Crosscutting concepts as boundary objects. In: J. A. Luft, & S. L. Dubois (Eds.), *Newly Hired Teachers of Science* (pp. 75-85). Rotterdam: Sense Publishers.

Nyikahadzoyi (2013). .....

Pitt, J. C. (1990). The myth of science education. *Studies in Philosophy and Education, 10*, 7-17.

Reutzel, D. R., & Cooter, R. B. (2012). *Teaching children to read: The teacher makes the difference* (6th ed.). Columbus, OH: Pearson Education.

Saldaña, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). Angeles, CA: Sage.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Slavit, D., & Lesseig, K. (2017). The development of teacher knowledge in support of student mathematical inquiry. *PRIMUS, 27*(1), 58-74. https://doi.org/10.1080/10511970.2016.1183156

Verloop, N., Driel, J. V., & Meijer, P. (2001). Chapter 1 Teacher knowledge and the knowledge base of teaching. *International Journal of Educational Research, 35*, 441-461. Retrieved from www.elsevier.com/locate/ijedures

Zimbabwe School Examinations Council (2016). *Zimbabwe School Examinations Council*. Retrieved from Ordinary Level Results Analysis: http://www.zimsec.co.zw/an-analysis-of-the-november-2016-ordinary-level-examination-results/

ZIMSEC (2010). Zimbabwe General Certificate Of Education Integrated Science (5006) O Level Syllabus For Examination in June/November 2011 – 2020. Zimbabwe: ZIMSEC.