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Evaluating the effectiveness of novice-teachers module designed to improve the professionalism of the Indonesian secondary school EFL novice teachers

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Abstract

The study aims to evaluate the effect of a Novice Teachers Module (NTM) on the content knowledge and the pedagogical performance of English as a Foreign Language (EFL) novice teachers and to explore their perception regarding the Module. The study used one group of pre-experimental design. Twenty novice teachers participated in the study. The instruments used in the study were a written test on EFL Content and Teaching Pedagogy and a questionnaire to measure perception on the NTM. At the beginning of the course, the novice teachers were given a pre-test about their content knowledge and their pedagogical skill including, text types based on the Curriculum 2013, creating tasks, managing large classes, motivating students, and assessment. Then the novice teachers were exposed to a workshop for nine meetings. In each meeting, they read the module and did the task in the *Discovery Activities*. Then they applied the concept of the topic in the *Link to your Context* section. After that, they presented the results to the class. Feedback was sought from peers and instructors. After the treatment, the participants were given a post-test. The results of the study revealed that the participants improved their scores on the content knowledge and pedagogical aspects. Their evaluation of the module was also positive.

Keywords: EFL novice teachers, novice teacher module, secondary school

1. Introduction

In general, discussing a second language or a foreign language, including English in the context of Indonesia, is a long and complicated process, because it is related to communications related to new words, as well as new ways of thinking and acting. Many research results prove the differences between the outcome variable, variable expenditure variable, linguistic variable, and learning variable. Variables of learner characteristics (Brown, 2007; Lightbown & Spada, 2001) are ranging from factors of age, intellectuals, commitment, and total involvement, as well as various affective factors such as motivation, needs, emotional conditions. The linguistic variable discusses the language that must be learned, while the learning variable includes methodological considerations, textbooks, teaching materials, institutions, and the teacher as the executor of learning. In other words, the teacher's factor in the frame of learning a foreign language is one of the essential variables in determining the success or failure of the language learning process, in this case, English. Therefore, in the context of English language education in Indonesia, to achieve the ultimate goal of the language, competent English teachers are needed.

In Law of the Republic of Indonesia Number 14 of 2005 concerning Teachers and Lecturers, Article 1 discusses professional teacher educators with the main task of educating, teaching, guiding, directing, training, assessing, and encouraging students in early children's education formal education training, education primary, and secondary education. As a professional educator, a teacher is required to have academic qualifications, competencies, and educator certificates, be physically and mentally healthy, and can achieve national education goals (Article 8). Specifically, the Republic of Indonesia Ministry of Education Regulation Number 16 of 2007 concerning Academic Qualification Standards and Teacher Competencies, secondary school teachers must have a minimum educational diploma qualification of four (D-IV) or undergraduate (S1) study programs following the subjects taught.

According to Article 8 of Law of the Republic of Indonesia Number 14 of 2005, a teacher should possess pedagogical, professional, and social competencies. Teacher certification is given to teachers who have met the requirements (Article 11, Paragraph 1).

Experience shows that novice teachers must directly engage in teaching in the context of the school. This situation provides a special challenge for novice

teachers, especially if in this new teaching location, there is not much professional assistance and support available to them.

Much research on novice English teachers has been carried out in an international context, which covers several aspects of novice teachers. Research by Brannan and Bleisten (2012), for example, shows that novice teachers desperately need peer support from mentors, both logistical and those related to professional and pedagogical competencies. The same thing was also found in the study of Mann and Tang (2012), which indicated that support was needed by beginner English teachers in Hong Kong because once they served in school, novice teachers had to meet the demands of effective performance and had to assume professional responsibility like an experienced teacher. Research by Senom, Zakaria, and Shah (2013) found various challenges faced by beginner English teachers in Malaysia, while research by Liu (2014) on the same topic was carried out in Taiwan.

Conversely, in the Indonesian context, research on teachers that have been done generally focuses on experienced teachers and professional teachers who have received educator certificates (for example, Irmawati & Widiati, 2016; Amin, 2013; Triyanto, 2012; Musthofa, 2011; and Anugerahwati, 2009). Irmawati and Widiati (2016) report on various activities carried out by professional English teachers in improving their pedagogical abilities. Previously, Amin (2013) had identified factors that caused English teachers to qualify for a professional title. Triyanto (2012), through the design of a case study, reports on the teacher certification program for English teachers in Indonesia. Research by Musthofa (2011) and Anugerahwati (2009) has a similar goal, namely exploring the professional journey of the model English teacher, but in the context of different types of schools, namely vocational schools, and public schools.

Due to limited research on novice teachers, information on the needs and challenges of novice teachers in Indonesia is unknown. This condition encouraged the writers of this article to conduct a need analysis of the EFL novice teachers (Widiati, Suryati, & Hayati, 2018). The needs analysis involved four junior high school teachers, three high school teachers, and four vocational teachers who have teaching experience under 5 years, found that all respondent teachers stated that there was no orientation program at school and almost all states that they do not have mentors, whether official or informal. They face various challenges in planning, implementing, and evaluating learning.

In planning the lessons, the challenges of novice teachers can be mapped as follows. The novice teachers find it difficult to design learning activities following the abilities of students who are mostly below average. This condition is possible because the novice teacher respondents teach in private schools, which are not well off. Attending the City Teacher Forum is not helpful; because of the differences in the students' social, economic background, and academic achievement. The novice teachers also find it difficult to design learning activities that can motivate students due to their lack of knowledge and skills in English subject. Also, novice teachers find it difficult to understand how to plan to learn under the 2013 Curriculum with all its complexity, especially in terms of learning assessment.

In carrying out learning the learning activities, the novice teachers stated that low student learning abilities and motivation were their main challenges. Also, they also had difficulty in using English as a language of instruction because of low student ability. The respondent teachers also felt the management of large classes and the inculcation of discipline and attention to learning as a challenge.

The low ability of students felt by respondents' teachers at all levels of education impacted on how the learning assessment was carried out. The main problem is how to provide an objective assessment to such students with low abilities. The complexity of the assessment by involving peer assessment and performance rubric for productive language skills such as speaking and writing also becomes a difficulty.

Another problem was related to being a reflective teacher. They have little knowledge of how to conduct classroom action research. They stated that they did not seem to understand the meaning of reflection fully, and most of them said they had never reflected on learning and had never conducted classroom action research.

Based on the results of the needs analysis, the Module was developed to overcome the challenges that novice teachers faced. The module aims to improve the professionalism of English novice teachers. The Module consists of 9 units: *Being a Novice Teacher, Principles of English Learning and Teaching, Lesson Plan Development, English Text types, Exercises, and Task Derives from Texts, Classroom English, Teaching Large Classes, Motivating EFL Students,* and *Assessment for, as and of Learning*

Each unit consists of 6 sub-heading: objectives of the module (Aims), the explanation of the concept (Key Concept) the exercise (Discovery Activity), and

the opportunity for novice teachers to apply the concepts discussed in their respective contexts (Link to Your Context).

2. Literature Review

2.1 Novice Teachers and Continuing Professional Development

Novice teachers can be interpreted as anyone who teaches new subjects or subjects for the first time (Farrell, 2012, p. 437). However, in general, the term novice teacher refers to those who have just completed pre-service teacher education and have teaching experience under three years. Thus, what is meant by novice English teachers is teachers who teach English lessons for the first time after they graduate from the pre-service teacher education program.

Farrell further (2012, p. 437) revealed that in the study of educational literature in general, it seems that there is no standard agreement on the definition of novice teachers and about a period indicating that the 'beginner' period can be said to have passed. From various research articles referenced, Farrell states that a 'beginner' period can mean a teaching period of at least one year, or less than two years (for example, Haynes, 2011), or a maximum of five years (for example, Kim & Roth, 2011), although in the end Farrell (2012) suggested that the three-year period seemed the most realistic. From this understanding, it is obvious that the term novice has nothing to do with biological age. In this study, what is meant by beginner English teachers are teachers who teach English for between a year and five years.

2.2 Previous Research on Beginner English Teachers

In the international context of teaching English as a second language (TESL Teaching English as a Second Language) or a foreign language (TEFL Teaching English as a Foreign Language), a lot of research has been done on novice English teachers, which includes several aspects of novice teachers. In 2012, Brannan and Bleisten found that novice teachers desperately needed peer support from mentors, both logistical and those related to professional and pedagogical competencies. English teachers also expect feedback and moral support from their mentors. In other words, mentoring programs by mentors were perceived very positively by novice teachers. The same thing was also found in the study of Mann and Tang (2012), which indicated that support was needed by beginner English teachers in Hong Kong because once they served in school, novice teachers had to meet the demands of effective performance

and had to assume professional responsibility like an experienced teacher. Other variables included in the study of Mann and Tang (2012) are the age and teaching experience variables of mentors. These two variables are also examined in-depth to determine the correlation between the quality of mentoring with the quality of the affective relationship between novice teachers and mentors.

Research by Senom, Zakaria, and Shah (2013) found various challenges faced by beginner English teachers in Malaysia. The study conducted by Senom, Zakaria, and Shah (2013) focused on various scholarship assistance for novice teachers, the experience of novice teachers in the first years of teaching, as well as the importance of a paradigm shift in the development of novice teachers. Each focus is explored in-depth to find the problems and challenges. In Taiwan, research by Liu (2014) shows that the identification of various issues and challenges faced by beginner English teachers can be used as a basis for developing more effective assistance and assistance programs.

Conversely, in the Indonesian context, research on teachers that have been conducted generally focuses on experienced teachers and professional teachers who have received educator certificates (for example, Irmawati & Widiati, 2016; Amin, 2013; Triyanto, 2012; Musthofa, 2011; and Anugerahwati, 2009). Irmawati and Widiati (2016) reported that from their observations and interviews, the findings were obtained about the activities carried out by professional English teachers in improving their pedagogical abilities, namely attending seminars or workshops, reading references from journals and books, following teacher meeting forums, and utilizing internet facilities. Each type of activity is then analyzed based on program coherence, active learning, and content knowledge. Previously, Amin (2013) has identified factors that cause English teachers to get the title as unprofessional teachers, as well as factors that cause them to qualify as professional teachers. Triyanto (2012), through a case study design, reports on the teacher certification program for English teachers in Indonesia. Triyanto comprehensively reports the types of certification programs that can be taken by teachers, such as portfolio assessment, remedial training, further education, and professional education. Research by Musthofa (2011) and Anugerahwati (2009) has a similar goal, namely exploring the professional journey of the model English teacher, but in the context of different types of schools, namely vocational schools, and public schools.

Research on novice English teachers is still rare to find in the Indonesian context. Even more challenging is to find the research on module development and evaluation for novice teachers.

2.3 Previous Research on Module Evaluation

Oribe, Tan, Untalan (2015) developed an interactive learning module (ILM) for pre-service teachers teaching Grade 7 science. They conducted a formative evaluation of the developed ILM among IT experts and tried out the ILM with the target users for feedback and revision. The module was developed following the systematic instructional K-12 curriculum of Grade 7 science. The researchers employed Rapid Application Development (RAD) as a research methodology, while Adobe Flash and HTML5 were used to create interactive simulations and animations of each lesson in the module. The module went through several formative evaluations after the review by the pool of IT experts and the tryout of the instructional materials with the target users. Pre- and post-tests were also done to find out if the developed interactive module is an effective tool for teaching. The evaluation revealed that the developed interactive learning module is a useful tool for teaching Grade 7 science, and students learned best when the module was incorporated in the presentation of the lesson.

Another study was conducted by Nardo and Hufana (2014). This study focused on the development and evaluation of Technical Writing modules to develop autonomous learning among students. The modules were based on needs such as special techniques in technical writing, constructing verbal to non-verbal data, writing conclusions from research findings, writing recommendations for research, stating research problems, among others. Module II was evaluated along with subject matter, vocabulary and structures, exercises, illustrations, and physical make-up. Module II was rated "Good" by the control (2.94) and experimental (3.12) students. The English teachers rated the modules "Excellent". The modules were evaluated fit for the curriculum, but it was suggested that providing illustrations for most of the inputs, inclusion of interpretation of results as part of research paper writing, and using similar fonts for all entries to improve the content of the modules.

The last study was conducted by Willmot and Perkins (2011). They investigated a module for mechanical engineering students that embraces competitive challenges, student-centered learning activities, problem-solving,

creative design, and skills workshops that were designed to sit alongside and provide motivators for a broadly traditional first-year curriculum. The evaluation used both qualitative and quantitative methods of inquiry and largely confirmed what had been noted anecdotally. The results of the evaluation view the module as having a positive effect on both student engagement and the development of student team working skills. It was also established that there had been an improvement in the working relationships between personal tutors and their tutees since the introduction of this module. Following the evaluation, additional minor changes were made regarding the types of tasks to suit the students' needs.

The present study focusses on the evaluation of a module developed for Novice Teachers of English subject in the Indonesian context. The Module will be called Novice Teacher Module (NTM).

Four research questions guide this study:

1. To what extent does NTM influence the learning performance of EFL Novice teachers?
2. What is the view of EFL novice teachers towards the use of NMT?
3. What are the views of an EFL teacher educator concerning the NTM?
4. What are the views of an educational technology expert concerning the NTM?

3. Methodology

This current study adopted a quantitative methods research design, in which data is gathered utilizing quantitative (i.e. pre- and post-tests and questionnaires) to investigate the impact of NTM on the learning performance of novice teachers of EFL, as well as exploring their evaluation towards NTM.

3.1 Research Instruments

An achievement test was designed to examine the impact of NTM on novice teachers' performance. The test covered Principles of English Learning and Teaching, Lesson Plan Development, English Text types, Exercises, and Task Derives from Texts, Classroom English, Teaching Large Classes Motivating EFL Students, Assessment for, as and of Learning. This test consisted of forty multiple-choice items covering six domains of Bloom's taxonomy, as follows: knowledge= 2 item (5%); comprehension= 4 items (10%); application= 6 items (15%); analysis= 8 items (20%); synthesis= 4 items (10%); and evaluation= 16

items (40%). As a one-group research design, the pre-test was administered to the participants to measure their learning performance before the intervention, with the identical test subsequently administered as a post-test at the close of the study period.

The study also employed a descriptive approach. A questionnaire was designed by the researcher to explore the novice teachers' evaluation of NTM. The Novice teacher questionnaire consisted of three aspects: the content, the attractiveness, and the usefulness of the module. In addition, the ELT expert questionnaire and an educational technology expert questionnaire was also developed to evaluate the NTM.

3.2 Subjects

The population of this study consisted of novice teachers attending (n=20 attending the Teacher Certification Program in Universitas Negeri Malang in Indonesia. Twenty pre-service EFL teachers who enrolled in the Subject Specific Pedagogy Workshop were considered as forming the study's purposive sample. As part of a one-group research design, the participants were taught using the Module during the first semester in the 2018 academic year. Besides, one ELT expert and one educational technology expert also participated in the study.

3.3 Procedures

The participants were initially divided into 6 groups of four or five students. Each group was required to work cooperatively and interactively during workshop activities. To familiarize pre-service EFL teachers with the NTM, a single topic was presented one week before the treatment period for the students to read the Aims, Introduction, and Key Concepts. The class was followed by a question-and-answer session lasting approximately thirty minutes, to allow for further clarification regarding the topic. Following this, the students do the Discovery Activities, and apply the concept and do the Link to Your Context Activities and present the results to the whole class, and feedback was provided for the presentation. Before the treatment, the pre-test was administered to the participants to measure their pedagogical knowledge. Students were invited to participate in a survey on the module to discover their evaluation of the different elements of the Module.

Table 1. - Novice Teacher Module Workshop

Meeting no.	Topic	Duration	Workshop Activities
1	Being a Novice Teacher	5 hours	Pre-class activity Reading the chapter individually in Class: Question-answer about the topic in groups, Do the Discovery Activities, Do the Link to Your Context Activities. Present the results of step 3 and 4 to the whole class Provide feedback for presenters or provide elaboration and expansion to the ideas presented.
2	Principles of English Learning and Teaching	5 hours	
3	Lesson Plan Development	5 hours	
4	English Text types	5 hours	
5	Exercises and Tasks Derived from Texts	5 hours	
6	Classroom English	5 hours	
7	Teaching Large Classes	5 hours	
8	Motivating EFL Students	5 hours	
9	Assessment for, as and of Learning	5 hours	

Following the completion of the treatment period, the posttest was administered, to measure the differences between the pre- and post-performance of the study group. Then, the participants were asked to fill in the questionnaire.

3.4 Data Analysis

In order to answer the research questions, the collected data were analyzed utilizing SPSS Version 23, using the Paired-samples t-test as an inferential statistical technique to compare groups and the descriptive statistical methods, including frequency, percentage, means, and standard deviations.

4. Findings

4.1 The Effect of Novice Teacher Module on the Novice Teacher Performance

Employing t-test for paired samples, the following hypothesis was tested:

Ho: There is no significant difference between the pre-test and post-test scores of the novice teacher performance.

Ha: There is a significant difference between the pretest and post-test scores of the novice teacher performance.

Table 2. - Learning Performance of Novice Teachers

Learning performance	N	Mean	Std. deviation	t	df	Sig. 2 tailed
Pre-test	20	5,4000	,75394	25,777	19	,000
Post-test	20	9,6950	,66608			

Table 2 shows the mean difference between the pretest and the post-test of the respondents. The mean of the pre-test is 5,40 with a standard deviation of 0,753, while the mean of the post-test is 9,695 and a standard deviation of 0,666. The mean difference of 4.295 showed that there was an increase in scores in the post-test. To determine the significant difference between the pre-test and post-test, the t-test was applied. It yielded a computed t-value of 25,777. The Sig.2 value is much lower compared with the value of 0.05 level of significance, thus the null hypothesis that states that there is no significant difference between the pre-test and post-test scores of the Novice Teachers' learning performance are rejected. The conclusion is that the Novice Teacher Module used by the respondents helped them obtain higher scores in the post-test; hence, the intervention workshop program is effective.

4.2 Results of Novice Teachers' Evaluation on the NTM

The researcher calculated the frequencies, and the means, to answer the second research question. The weighted means for the 4-point Likert scale items. The participants were asked to rate their responses towards NTM concerning the three dimensions (see tables 3, 4 & 5).

Table 3. - Novice Teacher Evaluation on the Content of the NTM (n=20)

Indicator	Frequency				
	SA	A	D	SD	Mean
The contents are helpful to the needs of novice teachers.	10	10	0	0	3.5

The contents are specific, relevant to the characteristics of novice teachers.	11	9	0	0	3.55
The activities and tasks are relevant to the needs of novice teachers.	9	11	0	0	3.45
The use of technical jargon/terms/words is accurate.	9	11	0	0	3.45
The materials are useful in improving the knowledge, skills, and attitude of novice teachers.	9	11	0	0	3.45
The objective of the chapters is measurable and achievable.	7	13	0	0	3.45
The questions are provocative.	10	10	0	0	3.5
The Introduction of the module is clear.	11	9	0	0	3.55
The Key Concept is easy to understand.	10	10	0	0	3.5
The Discovery activities meet the needs of novice teachers.	10	10	0	0	3.5
The activities in the Link to your Context are helpful for the novice teachers.	10	10	0	0	3.5
The activities are flexible, allowing the creativity of novice teachers.	9	11	0	0	3.45
The types of activities in the module relate to the short term and long-term goals of novice teachers.	9	11	0	0	3.45
The activities and tasks in the module are authentic	9	11	0	0	3.45
The direction in every activity/task is clear.	10	10	0	0	3.5

Table 3 shows the students' evaluation of the content of the NTM. As can be derived from the table, among the fifteen indicators, (2) the materials are specific, relevant with the characteristics of novice teachers., (8) clarity of the introduction obtained the highest weighted average mean 3.55. This was followed by the obtained mean score of 3,50 for item number (1) the contents are helpful to the needs of novice teachers, (7) the questions are easy to understand, the clarity of The Key Concept, the relevance of The Discovery activities, the helpfulness of the link to your Context are activities and the clarity of direction.

On the other hand, reliability of the tasks/activities (2), accuracy of the use of technical/jargon in the sentences (4), and usefulness of the materials in improving the knowledge, skills, and attitudes of the novice teachers, the measurability of the objective of the chapters, the flexibility of task to allow creativities of novice teachers, the relatedness of activities in the module to the short term and long term goal of novice teachers, and the authenticity activities and tasks in the module obtained a mean of 3,45.

Table 4. - Novice Teacher Evaluation on the Attractiveness of the NTM (n=20)

Indicator		Frequency			
	SA	A	SD	SDA	Mean
How attractive or interesting is the Novice Teacher Module, in terms of: Lay-out	12	8	0	0	3.6
Font size	7	13	0	0	3.45
Graphic	2	13	5	0	2.85
Tables	2	13	5	0	2.85
Drawing/ picture/illustrations	2	10	8	0	2.7
Colour	2	10	8	0	2.7

Table 4 displays the attractiveness of the NTM. The highest mean score was obtained by layout item (3,60), followed by font size (3,45) and graphics and tables (2.85), respectively. The lowest score was obtained by drawing/picture and colour (2.70). This results in the use of graphics, tables, drawing, and color must be noted and taken into consideration.

Table 5. - Novice Teacher Evaluation on the Usefulness of the NTM (n=20)

Indicator	Frequency				mean
	SS	S	TS	STS	
This module meets my needs as a novice English teacher.	12	8	0	0	3.6
The various theories/principles/examples presented in the module can be applied in my school.	6	14	0	0	3.3
This module can improve my pedagogical competence as a novice teacher.	5	15	0	0	3.25
This module can increase my professionalism as an English teacher.	8	12	0	0	3.4
I can use this Module to help me and others learn independently.	5	15	0	0	3.25

Table 5 displays the usefulness of the NTM. The highest mean score was obtained by the relevancy of the module in meeting the novice teachers' needs (3,60), followed by improvement of the novice teachers' professional development (3.40) and the application of theories and teaching principles in their classes (3.30) respectively. The improvement of pedagogical development and the use of the NTM for independent learning obtained a mean of (3.25).

4.3 Results of Teacher Educators' evaluation on the NTM

A teacher educator was asked to evaluate the NTM. The teacher educator is an expert in ELT and is a professor in teacher education at Malang State University who had a Doctoral qualification in the field of English Language Learning (ELT) and had more than 25 years of teaching experience. The results of the ELT expert assessment of the NTM are presented in Table 6.

Table 6. - Teacher Educator (ELT Expert) Response on the Module

No.	Aspects	Indicator	SA	A	D	SD
1.	*Self Instruction*	The Aims and Goals of the module are clear.	X			
		The Contents of the Module is specific to meet the needs of NT	X			
		Illustration, pictures, tables, and graphics are provided to support the learning materials/concepts.			X	
		There are sufficient questions/ tasks to practice the concepts.		X		
		There are sufficient questions/tasks for students to apply the learning materials.		X		
		The learning materials and tasks are contextual.		X		
		Language use is clear.		X		
		The chapter introduction is clear		X		
		The chapter's goals/aims are clear.		X		
		The key concept is clear.				
		The tasks/activities are authentic.		X		
		The chapter review is clear.		X		
		The learning assessment is clear.			X	
		There feedback section for students to check their learning performance.			X	
		There are lists of references for students to explore further about the topic.		X		
2.	*Self Contained*	The module contains all the learning materials relevant to the aims/goals.			X	
3.	*Stand Alone*	The module does not depend on other media or other learning resources.		X		
4.	*Adaptive*	The chapter in the module is flexible for a novice teacher to use.		X		
5	*Up-to-date*	The contents of the module are up-to-date.		X		

No.	Aspects	Indicator	SA	A	D	SD
6.	*User-Friendly*	The instructions are easy to follow – user-friendly.		X		

Table 6 displays the results of the evaluation by the ELT on the NTM. There are six aspects of the evaluation. In the aspect of self-instruction, the evaluator gave strong agreement to the goals and aims of the modules and the specificness of the contents to meet the needs of NT. Related to the other indicators, the evaluator gave her agreement but voiced her disagreement on the items of illustration, pictures, tables, and graphics are provided to support the learning materials/concepts, the learning assessment is clear, there feedback section for students to check their learning performance and the module contains all the learning materials relevant with the aims/goals. These indicators are not yet present in the module and action need to be taken to improve the quality of the module.

4.4. Results of Educational Technology Expert's Evaluation on the NTM

An educational technology expert was also asked to evaluate the NTM. The educational technology expert is a senior lecturer in the Education Faculty, at Malang State University who had a Doctoral qualification in the field of Instructional Design and had more than 25 years of teaching experience.

Table 7. - Results of the Evaluation from the Educational Technology Expert

No.	Aspects	Indicator	SA	A	D	SD
1.	Format	The use of column format is appropriate.		X		
		The use of paper size is appropriate.		X		
		The use of icons in the chapters is appropriate.			X	
2.	Organization	There is a concept mapping of all of the learning materials.			X	
		The learning materials are organized appropriately.		X		
		The use of pictures, illustrations, graphics, and other tools to support the texts are presented appropriately.			X	

No.	Aspects	Indicator	SA	A	D	SD
		The chapters and sub-chapters and paragraphs are organized neatly.		X		
		The chapter title, sub-chapter titles, and body texts are organized neatly.		X		
3.	Attractiveness	The cover is attractive.		X		
		The contents of the module are presented attractively.				
		Each section of the chapter is presented attractively.		X		
4.	Font size	The types of font used in the Module are appropriate.		X		
		The font sizes used for chapter titles, subchapter titles, and body texts are appropriate.		X		
		The use of capital letters is appropriate.		X		
5.	Space	The space between chapter titles and subchapter titles is appropriate.		X		
		The *margin* is appropriate.		X		
		The space between the column is appropriate.		X		
		The space between paragraphs is appropriate.		X		
6.	Consistency	Consistency is applied throughout the whole module.		X		

Table 7 displays the results of the evaluation by the educational technology expert on the NTM. There are six aspects of the evaluation. In all of the aspects, the evaluator gave agreement to all of the indicators. However, the educational technology expert did not agree with the three indicators: the appropriateness of the use of icons in the chapters, the absence of concept mapping of all of the learning materials, and the appropriate use of pictures, illustrations, graphics, and other tools to support the texts. These indicators are not yet evaluated positively, and action needs to be taken to improve the quality of the module.

The open-ended evaluation given by the ELT expert and educational technology expert is summarized below. The ELT expert thought that the formulation of the chapter goals needs revising:

"I think the goal of the chapters should be made clear. Use operational, specific, and measurable verbs." (ELT expert).

Also, the ELT expert was also concerned about the types of questions and tasks in the Module. She mentioned:

> *The questions and tasks should not only cover the low order of thinking skills, but you should also ask questions and provide tasks that provoke or includes high order thinking (HOT) skills. Because HOTs is necessary and has been the focus of teacher professional development. The case studies may serve as the basis for novice teachers to apply, analyze, and evaluate the concept that they learn in the module.*

Furthermore, the ELT expert and the educational technology expert agree about the need to use pictures, illustrations, graphics, and other tools to support the texts. The Educational technology expert stated that:

> *It will be very dull to read texts only throughout the module. It will facilitate novice teachers' learning and understanding. You add pictures, tables, charts, highlighter, and icons in each section to strengthen the message. Concept mapping is also necessary to give ideas to the novice teachers about the relationship of the learning materials. (Educational technology expert).*

5. Discussion

The findings revealed that NTM significantly improved the post-performance scores of EFL novice teachers. This could be due to: (1) continual exposure to the learning materials by (1) reading the materials individually, (2) multiple in-class activities facilitating the more efficient and creative use of learning materials; and (3) activities allowing learners to discuss the materials with peers, express opinions, ask questions, obtain assistance from peers or the instructors. Besides, they also answer the questions and practice to relate the concepts to their situations, which facilitate a deeper understanding of the concepts.

The findings concerning evaluation towards the NTM revealed that the novice teacher participants rated highly on the contents of the module which are

specific, relevant with the characteristics of novice teachers, clarity of sections of the module, and they are easy to understand. They think that the module is attractive, but it contains fewer illustrations, pictures, graphics, and other tools to assist the quick understanding of the concepts. They also think that the module meets their needs, and it can improve the professional, pedagogical, and attitude of the novice teachers. These findings corroborate with the findings of Oribe, Tan, Untalan (2015).

The evaluation by the ELT expert on the NTM revealed that the module has the characteristics of being self Instructed, Self Contained, Stand Alone, Adaptive, Up-to-date, and User Friendly. However, it needs more illustrations, pictures, tables, and graphics to support the learning materials/concepts, the learning assessment and the feedback section for students to check their learning performance and variety of tasks to suit the students' needs. These findings corroborate with the findings of Willmot and Perkins (2011).

The evaluation by the educational technology expert on the NTM revealed that the module has the characteristics of being self Instructed, Self Contained, Stand Alone, Adaptive, Up-to-date, and User Friendly. However, it needs more illustrations, pictures, tables, and graphics to support the learning materials/concepts, the learning assessment, and the feedback section for students to check their learning performance. This finding is also resonated by the result of the study conducted by Nardo and Hufana (2014).

6. Conclusions

The novice teachers who participated in the study have improved their performance in the form of obtaining higher scores in the area of Principles of English Learning and Teaching, Lesson Plan Development, English Text types, Exercises, and Tasks Derived from Texts, Classroom English, Teaching Large Classes, Motivating EFL, and Students Assessment for, as and of Learning.

Although the novice teacher participants, the ELT expert, and the Educational Technology expert who contributed to this evaluation view the module positively. Some areas need improvement. Specifically, it needs to be completed with concept mapping, icons to guide the readers' activities, variations of questions and tasks, learning assessment, and the answer key and the feedback section. All evaluators agree that illustrations, pictures, tables, and graphics to support the learning materials/concepts should be added to the module.

Based on the results and conclusions of the study, the following recommendations are presented: (1) Although some aspects need to be added to the module, the NTM fits to used for EFL novice teachers in Indonesia; (2) Since evaluation from the Novice Teacher respondent is important, their responses and performance become a basis for the refinement of the Module. Activities/tasks may be added/modified to enrich or improve the Module. (3) Concerning the evaluation provided by the university experts, it is highly recommended that these inputs to be reviewed and added to improve the module; (4) There is a need to test the novice teachers knowledge and application of skills in a variety of ways like in a quasi-experimental design to test the effectiveness of the module; (5) Needs analysis is a continuous process. It is important to identify some learning needs, which may have been overlooked and needs to be added to the module.

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Student teachers' understanding of the concept of culture

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Abstract

How do novice student teachers understand the concept of culture? To what extent do their understandings of the concept change after three years of teacher education? These questions are discussed based on insights about various scholarly concepts of culture, which have developed over more than a century. In addition, theories of localism and individualisation are used. We discuss findings from a longitudinal quantitative study, with data collected in 2014 and 2017 at a Norwegian teacher education institution. In addition to questions with predefined answering alternatives, the students were invited to answer the following open question: "Can you, in your own words, explain what you mean by culture?" In this paper, we analyse and compare the responses to this question in 2014, when the students began their studies, and in 2017, after three years of study. One interesting finding is that many students define culture in quite local and personalised terms, although more so in 2014 than in 2017. Another important finding is that static understandings of culture prevail in both 2014 and 2017, although less so in 2017 than in 2014.

Keywords: Culture, multicultural awareness, localism, individualisation

1. Introduction

Culture is a concept that is frequently used in education, in everyday life, and among scholars. In particular, the concept often turns up in debates about migration and ethnic majority-minority relations. Culture constitutes the basic term in compound concepts such as multicultural, intercultural, or transcultural. Still, such concepts seldom seem to be explained or defined in a thorough manner

among educators. Any clarification of the meanings of these concepts should start with the concept of culture itself. In the scholarly literature, there is a huge variety of understandings of the concept, particularly among anthropologists and sociologists, but less so among teacher educators. The student teachers of today will have to explain concepts such as culture, multicultural societies, and intercultural relations to new generations. It is thus relevant to ask how they understand the concept of culture, and how we may analyse these understandings.

The findings in this paper are outcomes of a study of multicultural awareness that we conducted among student teachers at a Norwegian Faculty of Education, in which both Kindergarten- and General Teacher Education students participated (Bugge & Løtveit, 2015; Løtveit & Bugge, 2015). The research is based on the students' responses to a structured questionnaire with mostly fixed answering alternatives. However, we also included a few open questions in the questionnaire, among them the following: Can you in your own words explain what you mean by culture? (Norwegian: «Kan du med egne ord forklare hva du mener med kultur?») A discussion of the responses to this question constitutes the basis of the article.

2. The Concept of Culture – A Literature Review

According to Raymond Williams, "Culture is one of the two or three most complicated words in the English language" (2014, p. 101). Throughout the last century or so, scholars have presented hundreds of definitions of culture. Renato I. Rosaldo underlines that "there is not a single, eternal definition of culture, but rather provisional definitions that will be revised as debates unfold through time. In part, the problem for analysis is to clarify the issues that divide parties to the debate" (2006, p. 11). Despite these challenges, according to Thomas E. Wren, "Few multicultural education textbooks or scholarly works acknowledge the complexities and historical evolution of the various conceptions of culture that one finds in the social sciences, where culture has always been a vigorously contested issue" (2012, p. 5).

Any attempt to provide a basic overview of different scholarly definitions of culture would require far more space than what is available here. Still, it might be worthwhile to highlight a few quite well-known definitions in order to provide a certain sense of how approaches to the concept have changed over time. According to Edward Burnett Tylor in *Primitive Culture* (1871), culture is "… that

complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society" (quoted in Street, 2019), a definition which is still used by some today. Tylor was an evolutionist who regarded societies as more or less advanced, and as progressively developing "from a savage to a civilized state" (Street, 2019). Franz Boas, the German-born "father of American anthropology", distanced himself from Tylor's evolutionism and from the distinction between primitive and advanced cultures. Boas maintained that "Culture embraces all the manifestations of social habits of a community, the reactions of the individual as affected by the habits of the group in which he lives, and the products of human activities as determined by these habits" (quoted in Wren, 2012, p. 30). Boas and his adherents distanced themselves from the racist connotations of many contemporary understandings of culture. A. R. Radcliffe-Brown considered culture as "a mode or process of social integration" (quoted in Wren, 2012, p. 38). Wren points out that to Radcliffe-Brown,

> Rules of morality, religious beliefs, rituals, and other so-called 'elements of culture' are important … only because they transform individuals into members of groups, and groups into interlocking parts of a society. In his view, the way to understand culture is not to ask what it is but rather what it does (Wren, 2012, p. 38).

Clifford Geertz defined culture as "a system of inherited conceptions expressed in symbolic forms by means of which men communicate, perpetuate, and develop their knowledge about and attitudes toward life" (Geertz, 1973, p. 89). According to a contemporary anthropologist, Thomas Hylland Eriksen (as quoted in Dahl, 2014), cultures are ". . . the ever-changing common meanings that are established and changed when people do something together." The above examples, even if few, should be enough to demonstrate how difficult it is to present a standard definition of the concept. Definitions of culture are and have long been a field of contestation and debates.

3. Methodology

It is not our intention to compare variations and tendencies in the scholarly definitions of culture with those of our student respondents. Neither, however, should we regard these two kinds of definitions as completely unconnected. At times definitions from the two areas overlap in some respects, and at other times they do not. In this paper, we have chosen to examine two questions that we

believe are significant for multicultural teacher education. First, who or what do the students focus or concentrate on as "proprietors" of culture or cultures? In other words, who or what has, practises or bears the stamp of culture/s, according to the students? Second, to what extent are the students' interpretations of the concept of culture dynamic (indicating potential for cultural change) or not?

We believe that definitions that somehow include or are compatible with understandings of culture as a general human phenomenon related to or embedded in social systems are better and more in accordance with the aims of multicultural education than definitions with more personalised or locally focused features. Furthermore, we believe that definitions that not only underline culture as something inherited from earlier generations, but also as something that is evolving and changing in contemporary life, are more promising than those that do not. Still, it is an open question whether or to what extent personalised, locally focused or static understandings of culture block or impair development of fruitful intercultural relations or intercultural competence.

Methodically, we have opted for a combination of quantitative and qualitative approaches. Responses to open questions should be analysed differently than responses to questions with fixed answering alternatives. We have on the one hand sorted the responses according to certain key words or combinations of words. On the other hand, we are aware that responses with similar key words may contain statements with different meanings. In the end, the meanings are more important than the key words as such. At the same time, the meanings of different statements are seldom completely unambiguous. It has thus been important to explore what possible meanings the students' statements may contain. Compared to a purely quantitative method, we have in this context looked for and discussed some evident tendencies that we see in the student responses. We have deliberately chosen not to quantify them.

The question was answered by student teachers in their first and third year of teacher education, and the data were collected in 2014 and 2017. The questionnaire was distributed to the same group of students on both occasions. The response rates were high (N1=388, N2=268, response rates 90% and 82%). In 2014, the number of respondents who answered the above question about culture was 240 (62% of the 388 total). In 2017, the corresponding number was 207 (77% of the 268 total). The questionnaires were distributed during lecture time and collected immediately after completion to avoid non-response. At every occasion, one of the researchers administered the data collection.

4. "Proprietors" of culture

Here we will present findings concerning who or what the students consider "proprietors" of culture.

4.1 Results

Who or what do the students focus on as "proprietors" of culture or cultures? We should perhaps expect student teachers to state that culture is something that societies, countries, or perhaps groups of humans have, practise, or are influenced by. Still, only a limited group of the students mention those categories. In fact, the students' responses are highly variegated. Some focus on "humans", others on "people" or "peoples". A few novice students in 2014 concentrated on "us" in various forms (i.e., "our traditions", "our values", or "our country"), while an even smaller group put their emphasis on otherness, i.e. "other countries", "other people" etc. (All translations from Norwegian to English in this text are our own).

The most noteworthy tendency in our material, however, although not necessarily a majority tendency, is for the students to describe culture as something close to themselves. If permitted, we might call this tendency for "nearness-isation". (The term is borrowed from Hotopf [2014], in which it has a different meaning). "Nearness-isation", as it is used in this text, takes two forms – first a widespread use of personal pronouns ("you" and "we" in particular, but also "I" and "me") or the general pronoun "one", which may both refer to people in general and to an unnamed person (the corresponding pronouns in Norwegian being "man" and "en"). Thus, culture is something that you have, we have, I have, or one has, practises, or is influenced by. A very few respondents go as far as to maintain that culture is purely individual. The second variant of the "nearness-isation" tendency is to highlight the importance of individuals' close environment, local community, and/or family/families. One example that combines both forms is this: "For me, culture is what I have inherited in my childhood, family, and community". Another example: "Everyone is different; [they] may have grown up in different cultures with respect to where you live in the country. The culture of the hometown/place of origin or identity through language, for example".

Thus, culture appears as something quite personal and tightly related to the respondents' local community life or personal network/environment. Perhaps the above respondents, as well as other respondents, think that culture must mean

the same for everyone else as it does for them, and thus is a global phenomenon. However, that is not what they put in writing, so we cannot simply assume this to be the case. Their focus is on what is close to them. Of course, there are also responses that seek to combine what is personal or near with more abstract or general concepts like "society." One example: "Culture is for me the traditions and experiences one gets through family and society." Furthermore, as indicated above, there are also responses with no traits of "nearness-isation" whatsoever. For one student teacher, for example, culture is "attitudes, values, and traditions that put its imprint on a society".

4.2 Discussion

How may "nearness-isation" be understood? At least four hypotheses are possible. 1) The respondents are young persons; many of them come from small towns and relatively tiny inhabited localities. For some, the new experience as student teachers may have brought them into contact with broader and more impersonal environments. In some cases, their responses may reflect a strong emotional attachment to the community of origin that they have left. 2) "Nearness-isation" may in addition or alternatively reflect a wider cultural trend, which is observable in mass media and in other contexts: News, politics, advertising, sports, popular music, education, and other parts of public life often make use of individual or personal stories and approaches or highlight the importance of individuals and individual choices. These may come at the cost of more general or impersonal trends or perspectives. Thus, a "you", a "me" or a "one"-perspective on culture may appear as "natural" to many young people today. 3) "Nearness-isation" may also reflect students' learning strategies. Culture is a very abstract and difficult concept. One way for students to construct a meaningful understanding of the concept may be to relate it to something concrete and familiar, something and someone to which the student teachers have first-hand relations. 4) A fourth possibility is that the responses reflect a lack of interest or understanding of the wider world.

A way of developing a theoretical framework that may help us understand the phenomenon that we so far have called "nearness-isation" is to regard it as a cultural expression of localism and individualisation. In this respect, Gabriele Pollini's endeavour to develop a theory of place attachment and socio-territorial belonging (Pollini, 2005), as well as Ulrich Beck and Elisabeth Beck-Gernstein's work on individualisation (Beck & Beck-Gernstein, 2002), can be helpful.

Pollini writes:

> Some of the approaches dominant within first the modernization paradigm, and then the globalization paradigm …, have often suggested the progressive loss of significance of particularist and diffused belonging to the local community ('delocalization') … with the corresponding emergence of a single cosmopolitan attachment/belonging of a universalist and specific kind. (2005, p. 502-503)

However, Pollini points out that increased spatial and residential mobility over the last few decades have not resulted primarily in increasing any single cosmopolitan attachment. Rather, local attachments appear to have multiplied. He sees a "diffusion within the population of a multiplicity of socio-territorial belongings … at the expense of belonging to one single territorial collectivity" (p. 512). He finds that "in the contemporary situation, localism may vary from intra-metropolitan 'neighborhoodism' through rural and urban municipalism, that of the area intermediate between commune and province – to 'provincialism (-regionalism)'" (p. 506).

So, instead of one specific 'traditional' and non-urban type of localism, which to some extent still exists, localism has taken new and more varied forms. Pollini found that besides "the more traditional form of 'belonging ascribed by birth and residence'", there are "non-traditional forms of 'belonging by birth alone'", as well as "'belonging acquired by residence' … and 'elective belonging'" (p. 507). The last may refer to people's attachment to places where they neither were born nor reside, but where they, for example, spend or have spent a lot of time on activities of their liking. Thus, we should be careful not to consider all forms of localism as old-fashioned, outdated, or merely nostalgic. New forms of localism may very well be a significant social response to globalisation, urbanisation, and increased geographical mobility.

Another approach to the challenge posed by "nearness-isation" is provided by Beck and Beck-Gernsheim's analysis of individualisation, of which we will only look at some basic features:

On the one hand, individualization means the disintegration of previously existing social forms – for example, the increasing fragility of such categories as class and social status, gender roles, family, neighbourhood etc. Or … it means the collapse of state-sanctioned normal biographies, frames of reference, role

models. Wherever such tendencies towards disintegration show themselves the question also arises: which new modes of life are coming into being where the old ones, ordained by religion, tradition or the state, are breaking down? (Beck & Beck-Gernsheim, 2002, p. 2)

Here, the second aspect of individualization appears, as "in modern societies new demands, controls and constraints are being imposed on individuals" (p. 2). Individuals are increasingly forced or induced to develop individual strategies to succeed. "For modern social advantages [in education, the labour market, the welfare state, etc.] one has to do something, to make an active effort. One has to win, know how to assert oneself in the competition for limited resources – and not only once, but day after day" (p. 3). To succeed or to avoid downward social mobility, one cannot rely on traditional procedures or collective actions or support in the same way as earlier generations did. One must make decisions and take individual actions in an increasingly complex social environment. For example,

> … another feature of the guidelines of modernity is that they act against, rather than for, family cohesion. Most of the rights and entitlements to support by the welfare state are designed for individuals rather than for families. In many cases they presuppose employment (or, in the case of the unemployed, willingness to work). Employment in turn implies education and both of these presuppose mobility or willingness to move. By all these requirements individuals are not so much compelled as peremptorily invited to constitute themselves as individuals: to plan, understand, design themselves and act as individuals (Beck & Beck-Gernsheim, 2002, p. 3)

At the same time, the authors point out that it differs "how far individualization processes – overt or covert – have advanced" (p. 5) in different groups, milieus, and regions. It is more fruitful to regard individualisation as a trend rather than as a something that describes the whole population. In any event, there is, according to Beck and Beck-Gernsheim, a tendency that not only the big questions of individuals' life, such as to secure an income, but also their routinised activities are scrutinized and questioned to a much greater extent than before: "It is precisely this level of pre-conscious 'collective habitualizations', of matters taken for granted, that is breaking down into a cloud of possibilities to be thought about and negotiated" (p. 6).

It is reasonable to suppose that such individualisation processes are more pronounced among young adults than among older generations. If we follow Beck & Beck-Gernsheim, we can consider individualism to be, at least partly, a result of processes of individualisation. It follows that individualism or individual approaches to social phenomena in contemporary society may, to some extent, be a result of current social conditions, and not only a consequence of the spreading of individualism as an ideology. Thus, the personalised approaches to culture that we found in our study may largely reflect the structures of everyday life of young student teachers of today.

At the same time, we may ask: Are understandings of culture that focus on local and close networks or on individuals a hindrance for developing intercultural relations or intercultural competence? In a broad and thorough sense, this may be the case. Still, such understandings are not necessarily any hindrance for developing intercultural relationships with individuals of different backgrounds at a local level. They may perhaps even contribute to the inclusion of immigrants or immigrants' children into local networks or groups with special cultural traits or identities.

In any event, our study gives reason to believe that teacher education to some extent increases the student teachers' ability to regard culture as a general phenomenon. It was more common in 2017 than in 2014 to combine personal pronouns and "one" with general terms such as "society", "country", or "group of humans" when indicating who has, practises, or is influenced by culture. An example from 2017: "Culture is a set of rules, attitudes, and values that you acquire as a member of society, and they mark you as a person". It is also somewhat more common in 2017 than in 2014 to avoid personal pronouns or "one" altogether. For example: "Culture is what humans create around themselves. The culture consists of attitudes, values, ways of behaviour within a specific group of people". Furthermore, references to the students' close environments, local communities, or families are fewer in 2017 than in 2014. There is, nonetheless, considerable continuity from 2014 to 2017 when it comes to who or what the respondents consider to be "proprietors" of culture.

5. Dynamic or Static Concepts of Culture

Here we will present findings concerning the respondents' understandings of culture as dynamic or static.

5.1 Results

The second question raised in this paper regards the extent to which the students' interpretations of the concept of culture are dynamic (indicating potential for cultural change). There are at best some very few understandings of culture from 2014 that can be considered dynamic. One example: "Culture is for me a description of how a society works at any time. Not only old traditions, but how it actually is." Another example: "Culture is traditions, [that is] changing. May be positive and negative. Culture may be safety, belonging, Nature, Local community." A third example: Culture is "that which we bring along from earlier [times], as well as new things which we provide society with. That [may] be so much! The culture may form our values, and we may bring both positive and negative aspects along." A few other, but less clear, examples could be mentioned. Most of them may at best be regarded as dynamic in the sense that they to some extent describe or make it possible to regard culture as a current, everyday phenomenon. However, at the same time, they do not describe culture as something that basically is inherited from the past. Thus, when we take into consideration that there were 240 responses to the culture question in 2014, dynamic presentations of culture are hardly evident at all. Many of the definitions include heritage-oriented and static models of culture.

When we come to the responses from 2017, there are notably more presentations of culture that are dynamic, and they are also generally more sophisticated than the few examples from 2014 mentioned above. One example: "Culture is the sum of norms, values, ways of life, laws, and rules that society consists of. The culture (of today) is the result of both the history and of the current globalisation and the addition of new citizens from other cultures." Another example: Culture is "a set of values, norms, traditions that is continually changing. [There] are many different types of cultures as well as subcultures related to these." A third example: "Culture is learning and inheritance. Culture is carried on from generation to generation but is modified/changed as it is continued. Something is removed, something is added. [It is] changing continually."

These definitions from 2017 are not only more dynamic than the ones from 2014. They are in many ways also more explicit and advanced. However, the examples just mentioned constitute only a relatively small fraction of all the 2017 responses. Most presentations were still quite static or, at least, not very dynamic. Thus, the changes from 2014, even if notable, are quite limited in scope.

It is interesting to note that in our questionnaire the respondents were also asked (with two fixed answering alternatives) whether culture should be considered as largely stable or largely dynamic. In 2014, 56% of the respondents ticked off for "largely dynamic". In 2017, 75% did the same. Thus, the difference is striking between the responses to the open question about culture and the closed question about culture. The responses to the open question about culture indicate that many of the responses on the fixed stable-dynamic question may not have been well embedded in the students' understanding.

5.2 Discussion

How may the preference among many student teachers for understanding culture as a basically static phenomenon be understood? One possibility is that their responses to some extent reflect what they have learnt at school, in mass media, and perhaps even in teacher education courses. Definitions with many similarities to the static scholarly definitions of the late 19th and early 20th century are still in circulation in textbooks, mass media, and elsewhere. It is, furthermore, tempting to suggest, but difficult to substantiate, that static understandings of culture may be of psychological importance to some respondents. In a world where much seems to change rapidly – technology, the labour market, job routines, fashion, trends, and politics – culture may appear as a stable sphere, a fixed feature of social life where it is possible to sense a kind of stability and continuity. In addition, how individuals understand their cultures may be linked to their identities. Certainly, Alejandro Grimson points out that culture and identity should not be confused, as "culture alludes to our routine of strongly sedimented practices, beliefs and meanings", while "identity refers to our feelings of belonging to a collective" (Grimson, 2010, p. 63).

However, even Grimson accepts that "in certain contexts, culture and identity can combine into a single practice, ritual or expression" (p. 63). Furthermore, static definitions may simply be easier to understand and remember than the dynamic ones, as the first in many cases simply include reference groups, for example societies or groups of humans, and a listing of certain elements or qualities (such as values, norms, knowledge, etc.) attached to those groups.

It is, moreover, interesting to note that Dahl, even when he promotes dynamic understandings of culture, does not completely reject the use of descriptive essentialist approaches to culture. He believes that they may be useful

- when we are searching for traits that are common to people with similar cultural backgrounds
- when we try to explain people's behaviour and acts in terms of their culture
- when we want to compare cultures
- when describing cultural differences (Dahl, 2014)

Essentialist or static approaches to culture are certainly difficult to avoid under all circumstances. If we should apply essentialist approaches in the way Dahl proposes, however, we ought to be extremely careful. The possible pitfalls of essentialist approaches are many. We might end up placing individuals in predetermined cultural categories and then compare them with other individuals placed in other predetermined categories. This could easily be understood as an invitation to regard individuals as belonging to either "us" or "them". That is exactly what intercultural or multicultural education should avoid and counteract.

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Investigating prospective mathematics teachers' meanings for and representations of functions: a study of pre-service teachers and of students of mathematics in an Irish university

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Abstract

The importance of teachers' – and hence prospective teachers' – knowledge of their subjects, especially in a form appropriate for teaching, has been well established by research. Also, in mathematics education, familiarity with and use of multiple representations has emerged as a key factor. These two fields of enquiry frame a small-scale international study the aim of which is to investigate prospective teachers' knowledge of the concept of *functions*. An instrument was designed to elicit the meanings that participants ascribe to the term "function" and the representations that they utilise for functions. For the component of the study reported in this paper, data were collected from pre-service teachers of mathematics and from undergraduate mathematicians taking a Mathematics Education module (and hence classified as prospective mathematics teachers) in one university in Ireland. The twenty-two responses were analysed with respect to how the meanings and representations reflected different approaches to teaching and learning about functions in Irish mathematics curricula over recent decades. The responses with regard to meaning reflected both structural and operational concepts of a function, and most participants provided multiple representations. However, in general the data do not indicate how participants might relate different approaches, especially for teaching. The small sample, restricted to one university, obviates any attempt to generalise from the findings, but they invite further investigation in the Irish setting and also feed into the larger study. It is hoped that the ongoing work will contribute to international

research on the design and content of mathematics teacher education courses.

Keywords: Teacher knowledge, representations, functions, prospective teachers.

1. Introduction

The importance of teachers' – and hence future teachers' – knowledge of their subjects, especially in a form appropriate for teaching, has been well established by research ongoing since the 1980s. For developing students' understanding of individual topics in mathematics, the use of multiple representations has emerged over the same period as a key area. Together, these fields of research provide a theoretical framework for ongoing investigations.

One such investigation is the study initiated in 2018 at the Annual Conference of the Association for Teacher Education in Europe (ATEE) by the Research and Development Community (RDC) "Science and Mathematics Education". Focusing on the concept of *functions* – a major topic in both mathematics and science education – it aims to examine the knowledge possessed by *prospective teachers* (that is, students in pre-service teacher education programmes involving science and mathematics, and those attending relevant courses or modules that attract students with an interest in teaching). The aims of the "Functions Project" are to address the following research questions:

a) What meanings do prospective teachers for primary and secondary levels, attending selected institutions in different countries, give to the term "function"?
b) What multiple representations do these prospective teachers associate with the term "function"?
c) What implications do the prospective teachers' descriptive meanings and representations have for teacher education courses with regard to functions?

An instrument was designed to elicit the meanings and representations. As a first exploration, members of the RDC administered it to selected groups of prospective mathematics teachers in institutions in three countries: Portugal, the Netherlands and Ireland.

This paper reports on the Irish component of the study. Several reviews of the Irish mathematics curricula have taken place since 1960, with the main definition

of a function and the chief representations utilised undergoing considerable change. In particular, a major reform of the post-primary school mathematics curriculum (for students aged around 12 to 18) was rolled out on a phased basis from 2008 (Oldham, 2019). The reform initiative, known as Project Maths, aimed to counteract undue emphasis on teaching procedural fluency at the expense of conceptual understanding and to promote a more informal approach to the teaching of mathematics. However, the focus on conceptual understanding necessitates a fully competent subject knowledge, allowing teachers to make connections between multiple representations of concepts and links between different elements of mathematics and indeed other subject areas (Askey, 1999; Smith, 2004). Thus, a topic of interest in Ireland is how prospective teachers' knowledge reflects curricular trends and prepares them for teaching the present post-primary curriculum. While addressing the project's research questions with regard to the Irish data, the Irish component of the study focuses especially on the issue:

d) How do the meanings and representations relate to the approaches to functions encapsulated in Irish curricula in the past sixty years?

In section 2 of the paper, a review of literature is provided. Section 3 addresses the methodology used for the study as a whole and in particular for the Irish component. Results are presented in section 4, with discussion and conclusions being presented in section 5.

2. Literature Review

Sections 2.1 and 2.2 address, respectively, teachers' and prospective teachers' knowledge. The function concept, and how it figures and has figured in Irish curricula, are outlined in sections 2.3 and 2.4. Based on this, theoretical frameworks for the paper are identified in section 2.5.

2.1. Mathematics Teachers' Mathematical Knowledge for Teaching

The last fifteen years have witnessed much research in conceptualising and assessing the kinds of mathematical knowledge that teachers draw upon or need to acquire for effective teaching, typically described as mathematical knowledge for teaching (MKT) (Ball, Thames, & Phelps, 2008; Stylianides & Ball, 2008). It encompasses both content and pedagogical considerations (Hill, Rowan, & Ball, 2005). Illustrations include explaining concepts to students, interpreting students'

answers, judging textbook explanations, using representations accurately in the classroom, and providing students with examples (Hill et al., 2005). Many studies have found that teachers' MKT is essential to the improvement of teaching and learning mathematics (National Mathematics Advisory Panel, 2008; Kulm, 2008) and has been linked with gains in students' achievement (Hill et al., 2005; Baumert et al., 2010).

However, research studies have shown evidence of inadequate MKT amongst teachers (Ball, 1990a; Ma, 1999). Many teachers exhibit a rule-based sense of understanding of the subject and this is reflected in their practice (Kulm, 2008). Schwartz (2008) noted that for teachers to be able to teach with an emphasis on conceptual understanding, they must have the conceptual underpinnings themselves.

2.2. Prospective Mathematics Teachers' Mathematical Knowledge for Teaching

The present study focuses on the knowledge and understanding of prospective mathematics teachers. Research indicates that many prospective teachers lack conceptual understanding of the mathematics they will be required to teach when they qualify (Ball, Hill, & Bass, 2005; Da Ponte & Chapman, 2008; O'Meara, Fitzmaurice, & Johnson, 2017). For example, Slattery and Fitzmaurice (2014) carried out a study to measure pre-service teachers' conceptual understanding of fraction division. The results showed that participants – who were nearing the end of their degree programme – had a fragmented understanding of the fraction concept, and were unable to explain the invert and multiply rule. They also could not produce any real-life examples to represent a problem related to the division of fractions, and relied on a series of "rules without reason" to answer the questions posed. Thus, when teaching, these pre-service teachers would have to rely on a series of learned procedural steps rather than focusing on understanding. Similarly, Ball (1990a) conducted a study with 252 pre-service teachers at the beginning of their teacher education and found that the mathematical understandings of the participants were mostly procedural and superficial, with only a minority able to express effective representations of dividing fractions. Ball's (1990a) results are in line with those of Li and Smith (2007), whose study of 16 pre-service mathematics teachers revealed that overall these teachers were procedurally competent, but conceptually unable to teach mathematics effectively.

The results of these studies all suggest that action is needed in order to improve prospective mathematics teachers' conceptual understanding of the subject and provide them with more learning experiences that promote a deeper exploration of mathematical content (Holm & Kajander, 2012).

Research indicates that too often initial teacher education (ITE) programmes do not positively alter teachers' r content knowledge. For example, Ball (1990b) underscored how participants in her study drew on the content knowledge they had developed in their own school experience, which tended to be procedurally orientated and superficial. Bryan (1999) noted that it is important that prospective teachers are given the opportunity to readdress the school curriculum on a conceptual level. If "school mathematics" is not revisited from a different and more advanced perspective in ITE, many of the same "naïve conceptualizations" of the content may be re-taught in the same manner when these pre-service teachers become qualified.

Changing such long-held practices presents a significant challenge to mathematics teacher educators globally. Irish studies to date have focused on prospective teachers' understanding of topics such as fractions, statistics, probability and – in another study for the ATEE RDC – ratio (respectively Slattery & Fitzmaurice, 2014; Hannigan, Gill, & Leavy, 2013; Hourigan & Leavy, 2019; and Costello, Stafford, & Oldham, 2018). The present study addresses the function concept.

2.3. The Function Concept

Watson, Jones, and Pratt (2013, p. 173) stated that a function is a relation in which "the value of a variable is dependent on one or more variables and particular values for the independent variable generate one and only one outcome." More formally, they defined a function as a mathematical relation such that each element of a given set is associated with a unique element of another set (the so-called uniqueness property). Viirman, Attorps, and Tossavainen (2010) noted that "function" is one of the fundamental concepts in modern mathematics. The concept has evolved over recent centuries, and the different historical understandings are reflected in curricula to the present day.

In a paper that addresses the nature of mathematics and also the ways in which it is learnt, Sfard (1991) distinguished between understandings of mathematical notions as objects (static structures, "existing somewhere in space and time") and

as processes ("dynamic, sequential, and detailed") (Sfard, 1991, p. 4). She referred to the two aspects as *structural* and *operational* respectively. Noting that the idea of a function was officially born at the end of the seventeenth century when use of algebraic symbolism was becoming widespread, she outlined three phases of development. They can be described as follows, drawing also on the work of Viirman et al. (2010):

- In the eighteenth century, Bernoulli and Euler used *operational* definitions typically linked to algebraic (or "analytic") expressions. A simple example of such an expression is $x^2 + 5x + 6$.
- A transition towards a *structural* definition came in the nineteenth century. In the work of Dirichlet, for example, every value of a variable x is said to correspond to only one value of variable y, independent of the form of the correspondence. This captured the uniqueness property and removes the reliance on algebraic expressions, allowing for inclusion of everywhere-discontinuous functions of the type that bear Dirichlet's name: functions with one value for rational arguments and another for irrational arguments.
- In the twentieth century, the Bourbaki group gave a purely *structural* definition that identified a function as a set of ordered pairs such that each first element is associated with exactly one second element (the uniqueness property). In the formal notation often associated with this definition, a function $f: X \rightarrow Y$ is a subset of the Cartesian product $X \times Y$ such that $(x, y_1) \in f$ and $(x, y_2) \in f$ implies $y_1 = y_2$. An important development is that the sets X and Y need not be sets of numbers.

  While the function concept is very important in school mathematics (Ubuz, 2007), it can also be abstract and difficult (Doorman, Drijvers, Gravemeijer, Boon, & Reid, 2012). O'Callaghan (1998) identified five areas of expertise with functions that need to be developed: modelling, interpreting, translating between representations, treating functions as objects, and, hence, being able to act on them. To achieve such expertise, students have to move between seeing functions as processes to conceptualising them as objects, and this encompasses a transition from an operational to a structural view (Tall, 1992). Likewise, Sfard (1991) suggested that the operational approach should precede the structural in teaching.

  With one of O'Callaghan's identified areas of expertise (translating between representations) in mind, Goos, Stillman, and Vale (2017) argued that functions cannot be fully understood within a single representation environment and that a multiple-representation approach should be used when teaching the concept.

Even (1990) contended that understanding a concept in one representation does not necessarily entail understanding it in another. Claiming that different representations give different insights which allow a better and more complete understanding of a concept, she argued that teachers need to understand concepts in different representations and be able to translate among and between them. Multiple representation can enable students to view and explore mathematical concepts in a variety of ways. For example, some features of functions are more apparent in graphic representations than they are in symbolic representations (Goos et al., 2017).

In order for teachers to be able to help students to be flexible in their approach to functions and link different representations, the teachers themselves need to have that knowledge and understanding (Even, 1990). However, research carried out by Doerr (2004) found that mathematics teachers had fragile understanding of the function concept. For example, Norman (1992) found that secondary school teachers did not show strong connections between their informal notions of function and formal definitions and were not comfortable with generating contexts for functions. Consistent with Norman's findings, Chinnappan and Thomas (2001) found that the prospective secondary teachers in their study had weak understandings of representational connections and limited ability to describe applications of functions. Doerr (2004) noted that the collective research in this area suggests that teachers' knowledge about functions tends to be procedural rather than conceptual, and to lack the kinds of connectedness and flexibility leading to teaching strategies that promote conceptual understanding by students.

2.4. The Function Concept in the Irish Post-primary Curriculum

Irish mathematics curriculum specifications are set out in official documents published over the years (see for example Department of Education, n.d. [1964], n.d. [1968], n.d. [1972], n.d. [1989], n.d. [1992]; Department of Education and Science, 2000; Department of Education and Skills, 2013, 2017). Curricular intentions can be judged also from papers set for the State examinations: the Junior Certificate (formerly the Intermediate Certificate), taken by students at around the age of 15, and the Leaving Certificate, taken at the end of the final year of schooling. An archive of papers is maintained by Malone and Murray (2019). Mathematics courses are offered at different levels; the provision and names have

changed over time, but it suffices here to use the current designations, "Higher", "Ordinary" and "Foundation".

The style of the curriculum specifications has altered greatly since the mid-1960s. Prior to that, specifications were very brief (see for example Department of Education, n.d. [1964], pp. 60-61); the detailed scope of the courses is seen largely from the examinations. Papers for the Leaving Certificate illustrate an operational approach to functions, emphasising algebraic expressions, with the notation "y =" used explicitly or implicitly (the latter, for example, via use of $^{dy}/_{dx}$ in questions on differentiation) (Malone & Murray, 2019).

During the 1960s and early 1970s, major curricular reforms entailed introduction of material strongly influenced by the "modern mathematics" movement (Oldham, 2019). With regard to functions, a structural approach was indicated via the specification for the Leaving Certificate course introduced in 1964: "A *Relation* as a set of ordered pairs. A *Function* as a relation in which each element of the domain belongs to only one pair" (Department of Education, n.d. [1968], p. 117). From 1966 the specification appeared more briefly in the Intermediate Certificate courses, initially in the form "Cartesian product of two sets. Relations and functions" (Department of Education, n.d. [1968], p. 58) and in later versions as "Function (map) as a special relation" (with notation "f: $x \rightarrow$") and "Function as a special relation" (Department of Education, n.d. [1989], pp. 49, 54). The notation "$f(x)$" appeared in Leaving Certificate examination papers in the later 1960s, for example in questions on composition of functions; "$f: x \rightarrow$" figured in those from the early 1970s, the most "modern" period for Irish curricula (Malone & Murray, 2019; Oldham, 2019). At that time, the intended emphasis was on a static interpretation, also applying to transformation geometry; the first author (teaching in the 1970s) recalls that the idea of points "moving to new positions" was regarded with disapproval. However, the structural interpretation coexisted with an operational approach in the traditional work on functions, for example in graphs and calculus.

Many "modern" topics faded out of the curricula in successive revisions from the mid-1970s onwards (Oldham, 2019). Nonetheless, aspects of the structural approach to functions remained. The Leaving Certificate curriculum introduced in 1992 listed both structural and operational aspects for the Ordinary level course, actually mentioning the Dirichlet function as an example of a function not defined by an algebraic expression. This was also the first course to state explicitly that students should know the three forms of notation: "y =", "$f(x)$ =" and "$f: x \rightarrow$"

(Department of Education, n.d. [1992]). Reference to these three forms has continued in subsequent curricula.

A revised Junior Certificate curriculum introduced in 2000 still referred to couples, domain and co-domain, and – at Foundation level – relations, and so can be seen as having a structural element in its approach to functions (Department of Education and Science, 2000). However, the guidelines produced to support implementation contained a "lesson idea" using the operational analogy of a function machine and the language of input and output (Department of Education and Science / National Council for Curriculum and Assessment, 2002, p. 79). The curriculum introduced in the Project Maths reform, described above, states that students should "engage with the concept of a function (that which involves a set of inputs, a set of possible outputs and a rule that assigns one output to each input)" – perhaps intending to highlight the operational aspect, though elsewhere the document retains the language of domain and co-domain (Department of Education and Skills, 2013, p. 30). The associated professional development for teachers made use of the "machine" analogy, which proved popular (Claire Cooper, personal communication, 9th August 2019).

In summary, it can be seen that from the 1960s the structural and operational approaches, together with notations typically associated with them, have been intertwined in the official documentation (curriculum specifications, State examination papers, and guidelines and support material for teachers). However, study of the examination papers indicates that questions focused entirely on structural aspects have been rare since the 1970s (Malone & Murray, 1999).

Despite its central place in the post-primary curriculum, the function concept has been identified as an area of difficulty for Irish students. The 2015 Chief Examiners' reports for both Junior and Leaving Certificate mathematics noted that many students had difficulty with understanding and working with functions (State Examinations Commission, 2019). For example, for the Leaving Certificate Ordinary Level Paper 1, two of the three questions having a mean mark below 50% were based on functions (Question 5 (functions) and Question 9 (functions/graphs)). Similarly, for the Junior Certificate Higher Level Paper 1, the question with the lowest mean mark (35%) was based on graphing functions. This question required students to make connections between a function and its graph (see Malone & Murray, 2019). The report notes that a large proportion of candidates did not successfully engage with this question at all, and this highlights the difficulties that students encounter when translating between

representations. The latest Junior Cycle specification puts additional emphasis on this aspect (Department of Education and Skills, 2017).

2.5. Theoretical Frameworks

While the whole study described here is framed by the concepts of teacher knowledge and representations, the frameworks used for data analysis refer specifically to work on functions. As mentioned previously, Sfard (1991) determined that any mathematical concept can be defined both structurally and operationally. Viirman et al. (2010) noted that the teaching sequence she advocated follows the historical development of the function concept, going from an operational to a structural view. In their study of pre-service teachers and engineering undergraduates starting a course on calculus, they used five categories of definition (henceforth designated as "the Viirman categories/classification"):

1. **Correspondence/dependence relation.** A function is any correspondence or dependence relation between two sets that assigns to each element in the first set *exactly* one element in the other set. Domain and range may or may not be mentioned.
2. **Machine**. A function is a "machine" or one or more operations that transform variables into new variables. In this case no explicit mention of domain and range is made.
3. **Rule/formula.** A function is a rule, a formula or an algebraic expression. Compared to the second category, the difference is that now regular behaviour is expected whereas the machine could conceivably perform totally different transformations of different elements.
4. **Representation**. The function is identified with one of its representations.
5. **Nonsense**. A meaningless answer or no answer at all.

(Viirman et al., 2010, pp. 11-12)

Both the Viirman and the Sfard categories provide guidelines to support data analysis with regard to *meanings*. There is evidence that they may reveal interesting differences. Viirman et al. (2010) found that their – Swedish – students' definition of functions could mainly be described as process-oriented and that

few presented structural definitions (category 1 above). However, Martinho and Viseu (2019), in the Portuguese element of the Functions Project, identified a predominance of structural responses.

For *representations*, work such as that of Goos et al. (2017), cited above, suggests use of categories such as word (text), number, graph, table and symbol form. These can perhaps be reduced to three broad categories: pictorial, symbolic, and textual.

3. Methodology

For the international study, which involves groups speaking different languages, the RDC chose to use a short written questionnaire (hence, obviating the difficulties that might have arisen, for instance, with processing data from extended interviews). The group developed an instrument based on one used in a similar RDC study (on the concept of *ratio*; see for example Costello et al. (2018)). This contained four open questions – one in two parts – allowing participants to describe their knowledge of the meanings, uses and representations of ratio.

The corresponding four questions, or items, for the Functions Project are as follows:

1. What does the term "function" mean to you?

2a. When do you yourself use functions?

2b. Who else uses functions, and when do they use them?

3. Which mathematical symbol(s) do you use to represent functions? You may write expressions that include the symbols, rather than just the symbols themselves.

4. Show how you would explain the concept of "function" (not using words only!). Give a few examples if you can. Present your ideas here and/or overleaf as you wish.

Question 4 allows the participants to demonstrate some pedagogical MKT. The four questions were set out on a single page of A4 paper, also providing introductory and classifying material, as shown in Figure 1.

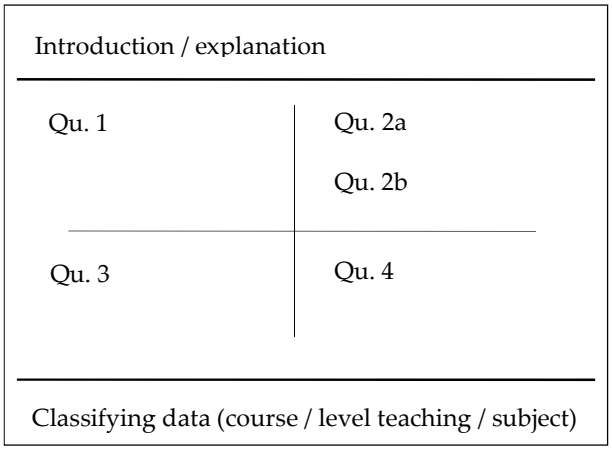

Figure 1. - Layout of the questionnaire

It was intended that data collection could be completed in about fifteen minutes, say at the end of a class period, thus making minimal demands on scarce teaching time.

For the Irish component of the study, two groups in one university were selected: pre-service teachers of mathematics (in the first year of their two-year professional Master's programme leading to national accreditation) and undergraduate mathematicians taking a Mathematics Education module that involves them in helping students in school or other classrooms (hence being considered as prospective mathematics teachers). The pre-service cohort was unusually small: only 5 students in the year 2018-19. Ethical clearance was obtained from both the School of Education and the School of Mathematics.

The data were coded using categories suggested by the actual data but also influenced by curricular issues and the frameworks on functions and representations. Thus, coding for question 1 reflected the different definitions of a function; for question 3, heed was taken of the symbolic representations in the curriculum specifications; and for question 4, the various types of representation were identified. Question 2, dealing with applications, is not considered in this paper. One author carried out the initial coding, noting for each participant the category or categories of response per question, and also identifying multiple occurrences of the same representation where relevant. The coding was then checked by the other author, and differences (where they appeared) reconciled by discussion. For each of the questions considered, the frequencies of use of relevant categories were calculated; the results were then interpreted in terms of curricular/historical background and type of representation.

4. Results

Completed instruments were received from 22 students: 18 from the class of 25 mathematics undergraduates and four from the class of five first-year pre-service mathematics teachers. The description by gender and age is shown in Table 1.

Table 1. - Participants by group, gender and age range

Group	No.	Gender (M/F)	Age range (years)
Mathematics undergraduates	18	11 M, 7 F	19-23
Pre-service teachers	4	1 M, 3 F	22-31

Because of the small number of pre-service teachers, the responses from the two groups in general are not reported separately; also, examination of the responses by gender is outside the scope of this paper. The participants' ages suggest that they would have encountered the changing curricula due to the Project Maths initiative during their school and undergraduate careers – though some participants may have been at school in other jurisdictions. Responses to questions 1, 3 and 4 are described in turn.

4.1. Responses to Question 1

Inspection of the data revealed that, while there was a reasonable fit with the Viirman classification, some responses contained aspects of two categories; notably, uniqueness and domain/range were mentioned by several participants alongside meanings that otherwise fitted the "machine" or "rule/formula" classifications**.** However, categorisation using the Sfard classification – "structural" versus "operational" – was more straightforward. Thus, meanings that primarily reflected a formal set-theoretic definition, or a less formal one referring to mappings or relations, were classified as structural; those that focused chiefly on a function as an operation, a process, a formula or an equation, or used the analogy of a machine, were classified as operational. References to uniqueness, input/output, and domain/codomain/range were allowed with either classification where appropriate. For two suggested meanings, it was impossible to decide on the major focus, so they were counted in both categories. One

response gave the meaning "graph"; this accorded with the Viirman category identifying a function with one of its representations. The number of participants giving a response or responses in each category is shown in Table 2.

Table 2. - Number of participants using each category – question 1

Category	Type	No.
Formal set-theoretic, less formal mapping or relation, object	Structural	12
Operation/ process/formula/equation, machine analogy	Operational	14
Graph	[Representation]	1
Input-output aspect mentioned	*With either*	*15*
Uniqueness mentioned	*With either*	*8*

Two participants provided both a structural and an operational version. One pre-service teacher wrote "A function is a relationship between two sets that [has the uniqueness property]" and also "it is a machine/map which changes something following a specific process…"; one mathematics undergraduate stated that "A function, formally, is a subset … of A×B… [with the uniqueness property]. Informally, it is an operation…."

4.2. Responses to Question 3

The data for question 3 mainly reflected the various representations used in the Irish curriculum specifications. Responses were categorised as: those that started "y ="; those that started "f(x) = "; those that started "f:"; and other. The middle two were subdivided as shown in Table 3. The notation "y =" antedates the appearance of the set-theoretic definition of a function in the curriculum specifications, and is classified as operational. The notation "f(x) =" came to prominence in the early "modern" period, but latterly has figured in examination papers chiefly in operational contexts (Malone & Murray, 2019). As the notation "f: $x \rightarrow$" was introduced at the height of the "modern" period, notably in "modern" contexts, it is tentatively categorised as in the structural tradition, although some of the responses provided an operational rule such as $x \rightarrow 2x + 1$. The notation f: $X \rightarrow Y$ is likely to have been experienced at university level, the focus on sets placing it cautiously in the structural category. As noted in table 3, only four participants provided just one example.

Table 3. - Number of participants using each category – question 3

Category	Type	No.
y = , y = algebraic expression, y = f(x)	Operational	6
f(x) = y, $f(x_1, \ldots, x_n) = (y_1, \ldots. y_n)$	Operational	6
f(x) = …, $f(x_1, x_2, \ldots x_n)$ =	Operational	14
f: x→y, x→ …	Structural?	4
f: X→Y	Structural?	9
Other	[Various]	11
Only one example given		*4*

4.3. Responses to Question 4

Participants offered a range of representations that could be classified broadly as pictorial, symbolic or textual. Among the pictorial representations, some were arrow diagrams (associated with the structural approach); some involved a diagram indicating input, process and output (hence, in general, operational); and some could be classified as drawings (rather than diagrams), again encapsulating the operational input-process-output metaphor. Cartesian graphs, typically reflecting an operational rule, also are classified as pictorial; tables are perhaps a borderline case. Textual explanations were often accompanied by symbolic or pictorial ones, the symbolic versions in particular rarely occurring on their own. The frequencies are shown in Table 4.

Table 4. - Number of participants using each category – question 4

Category	Type	No.
Arrow diagrams	Pictorial/structural	6
Input – function box – output diagrams and variants	Pictorial/operational	9
Drawings [using input-output]	Pictorial/operational	3
Graphs	Pictorial/operational	2
Tables	Pictorial?/operational	1
Symbolic *(usually alongside diagram or text)*	Symbolic/most operational	12
Text explanation *(often alongside other representations)*	Textual/most operational	15
Only one example given		*5*

Both structural and operational representations were presented, with much more focus on the latter. Most participants used more than one representation, and in general more than one form of representation, in some cases clearly focusing on

the relationship between them. The variety of responses is illustrated in Figures 2a-2d (mathematics undergraduates) and 3a- 3c (pre-service teachers). While the samples are too small to allow for meaningful comparisons of the groups, it is perhaps of interest that two of the pre-service teachers' responses pictured here showed pedagogical as well as content-oriented aspects of MKT: giving a counter-example (3b) and an application (3c).

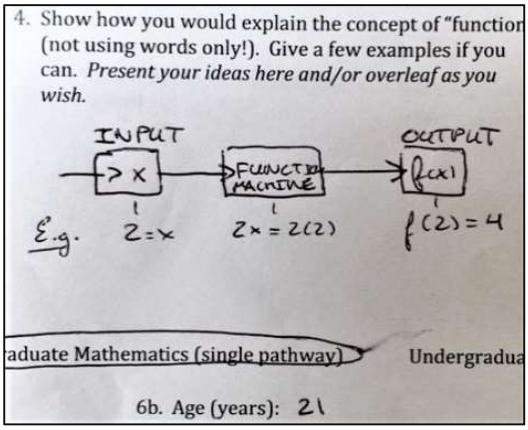

Figure 2a. - Mathematics undergraduate – primarily pictorial (input-output diagram) with symbol use

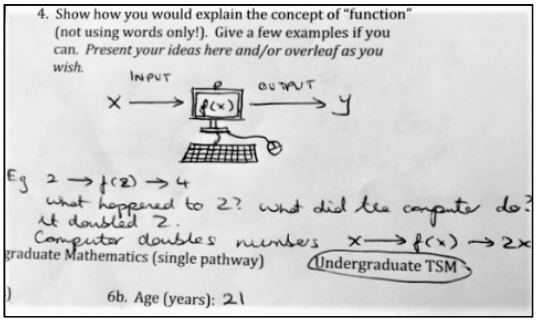

Figure 2b. - Mathematics undergraduate – pictorial (input-output drawing) with text and symbols

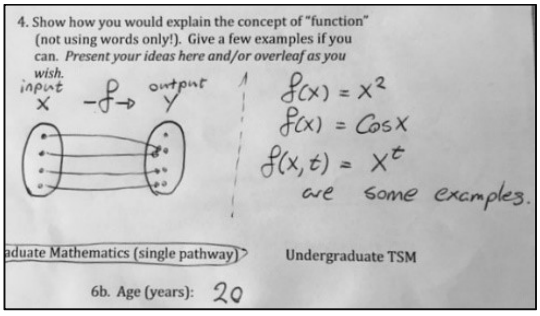

Figure 2c. - Mathematics undergraduate – pictorial (arrow diagram) with symbols

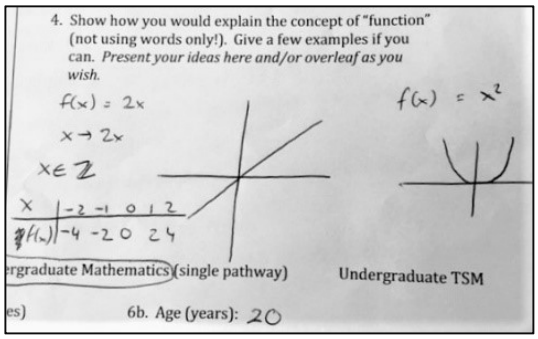

Figure 2d. - Mathematics undergraduate – pictorial (graphs) with symbols and table

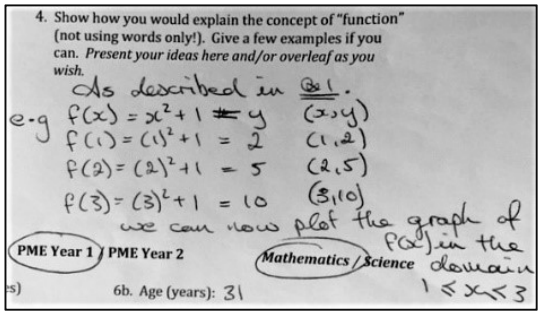

Figure 3a. – Pre-service teacher – primarily symbolic but reference to a graph

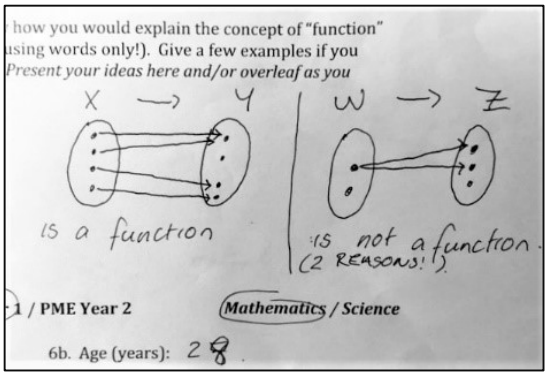

Figure 3b. – Pre-service teacher – pictorial (arrow diagrams), with example and counterexample

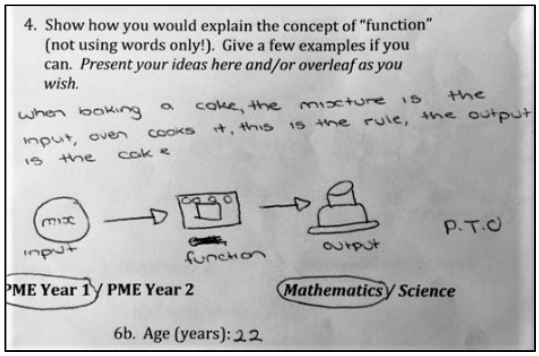

Figure 3c. – Pre-service teacher – pictorial (drawing of baking process) with text (also on reverse of sheet)

5. Discussion and Conclusion

The study described in this paper is the Irish component of a wider project examining prospective teachers' meanings for and representations of the function concept and their implications for teacher education. The Irish participants were drawn from two groups at one university: pre-service teachers aiming to qualify as post-primary teachers (of students aged approximately 12 to 18), and mathematics undergraduates taking a module on mathematics education. The paper examines the relationship between, on the one hand, meanings and representations given by participants in responding to the short data collection instrument used in the project, and, on the other, various forms of definition and representation of functions that have appeared in Irish post-primary curriculum specifications over the past sixty years. Structural and operational aspects of the function concept have been emphasised to differing extents over that time, and the responses regarding both meanings and representations reflect coexistence of the two strands.

The analysis may identify the curricular traditions more accurately than participants' exact understanding of the function concept. Developing robust coding for classification is still a work in progress within the whole project, and other classifications could be made. However, as suggested earlier, the frameworks identified in this paper appear to have potential to reveal interesting results that highlight differences in national curricula, notably with regard to structural and operational approaches (Viirman et al., 2010; Martinho & Viseu, 2019).

It appears that some Irish participants have grasped both structural and operational aspects, and can relate the two. However, echoing results from the literature, it is not clear if participants have sufficient MKT to help their students develop the dual concept. More may be learnt from further work, for example using the completed instruments in class as the basis for teaching, rather than data collection (Costello et al., 2017); discussion of participants' responses might clarify if some of them mask deep understanding while others obscure confusion or incomplete conceptions. The role played by textbook presentations – outside the scope of this paper – should also be examined.

Bearing the results in mind, it is important that ITE lecturers are aware that prospective mathematics teachers are entering their courses with varying levels of MKT for various topics such as functions. It is crucial that any deficits in knowledge are addressed in their ITE and do not continue post-graduation and

into their teaching careers. ITE programmes like the Irish one considered here, which takes place over two years, can provide students with the opportunity to construct conceptual understanding of topics relevant to their teaching. As noted by Artzt, Sultan, Curcio, and Gurl (2012), affording prospective teachers the opportunity to revisit secondary school mathematics content from an advanced perspective is essential for their preparation to teach mathematics meaningfully. This can result in new viewpoints about the teaching of mathematics and new thinking about learning, about their students, and about themselves (Bonner, 2006).

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Global teachers: The long-term effects of an international practicum

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Abstract

This paper present finding from an international practicum programme for Norwegian student teachers in Namibia. Inland Norway University of Applied Sciences offers three months international practicum programme in Namibia. The aim of the programme is to expose the students to diversity, develop their global and intercultural competence and to prepare them for teaching in multicultural classrooms in Norway. This paper is the last in a series of publications from a trailing research project following student teachers that had a 3 months international practicum in the global south (Wikan and Klein, 2017, Klein and Wikan 2019). In this paper, we examine the long-term impact of the experience. Based on a qualitative study with open-ended questions mailed to 18 former students we discuss the perceived impact of their experiences both personally and professionally, with a focus on the global teacher aspect. The main finding is that the international practicum has had a significant impact on both personal growth and professional development. They report that they feel competent to teach in a multicultural classroom, teach global issues, have broaden their worldview and global knowledge and have become more critical towards international news due to their own three months experience in Namibia. In conclusion, they have developed a cultural sensitivity and global perspective in their role as a teacher.

Keywords: International practicum, long-term effects, global teacher

1. Introduction

The consequences of globalisation are a challenge to teacher education. Conflicts, inequality and poverty has fueled international migration, which has resulted in increased ethnic and cultural diversity in schools around the world. Global interdependence is becoming more evident for most people as global migration and climate crises affect daily life. The sustainable development goals (SDGs) of the United Nations have been approved by most countries, and in order to meet these goals, we must educate all learners to take a global perspective.

To meet these SDGs, Norwegian education authorities launched new curricula for teacher education in 2017 and for primary and secondary schools in 2019. The new curricula focus on global issues, democracy, sustainable development and intercultural understanding as integrated components of the teaching of all subjects (https://www.regjeringen.no/no/dokumenter/f-06-16/id2507752/). These new curricula meet the need for competence and relevance in an increasingly globalised world. In addition to the new global focus of these curricula, international student mobility is being encouraged in all higher education programmes. The Ministry of Education of Norway is aiming for 50% of students to spend part of their education abroad. International exchange programmes are seen as a means for increasing the global perspectives and intercultural competence of students. These programmes are potentially transformative in nature as participants can gain a better understanding of and sensitivity to differences by living in another country and developing a more ethnorelative perspective. The new frame of reference would be considered more functional when it is more inclusive, differentiating, critically reflective, open to other points of view, and integrative of experience. Transformative learning is the process of change in frame of reference (Bennett, 2004, 2012; Mezirow 1981, 1997). First-hand knowledge and the experience of otherness are critical to the development of intercultural competence and global awareness, which are both necessary competences for teachers in diverse classrooms (Cushner, 2007; Stachowski & Sparks, 2007; Walters et al., 2009). Nevertheless, "many teachers continue to graduate from preparatory institutions and settle into careers without the requisite competencies to ensure the educational equity that enables all students to attain their personal and professional goals in this global, postmodern world" (Cohen & Mahon, 2009, p. 307).

Many researchers have found that students who take part in international exchange or international practicum programmes develop a more sophisticated worldview, become more interested in exploring other cultures, increase their openness and tolerance towards other cultures and gain a greater understanding of global issues (Chieffo & Griffiths, 2004; DeGraaf, Slager, Larsen, & Ditta, 2013; Maynes, Allison, & Julien-Schultz, 2012). In addition, these students also report personal benefits, such as increased independence, maturity and confidence, and for student teachers, this personal growth also strengthens their abilities as teachers (Nunan, 2006; Tangen et al, 2017; Wiggins et al., 2007; Wilson 1993).

However, some scholars have questioned the transformative power of exchange programmes (Bathurst & La Brack, 2012; Lou & Bosley, 2012; Vande Berg et al., 2012). They have claimed that being in another country does not automatically make a person interculturally competent (Hammer, 2012). While being exposed to another culture is a necessary condition for students to become interculturally competent, it is insufficient. Some students have learned to appreciate the differences between cultures, opened their minds and increased their acceptance of differences. However, others have returned with a stronger belief in the superiority of their own culture (Klein & Wikan, 2019; Wikan & Klein, 2017). Note that these prior findings were based on data gathered shortly after the student teachers completed their programmes. Therefore, these studies have evaluated short-time effects.

There are few studies on the long-term effects of international mobility (DeGraf, Slager, Larsen, & Ditta, 2013; Nunan, 2006,). Those that have studied the long-term effects have found some lasting personal and professional ones. On the personal level, they have found improved language skills, increased self-esteem and greater interest in international affairs. On the professional level, studies have found an impact on curricular and instructional practices (Hadis, 2005). This article supplement to these studies by analysing the long-term effects of a Norwegian international practicum programmes. The participants that is presently working as teachers took part in a 3-month international practicum programme for student teachers in Namibia. The aim of the programme was to expose students to diversity and to develop their global and intercultural competences so that they are better prepared to be global teachers in the 21st century. They had their practicum in primary and lower secondary schools in a medium-sized town in northern Namibia. In this article, we investigate how the

participants evaluate the value of international practicum after having practiced as teachers for some years. We especially address issues such personal and professional growth, gaining a global perspective and intercultural competence.

2. Literature Review

Global education has many definitions but they all includes both a knowledge dimension and a perspective dimension. Based on the UNESCO definition, Becker (1982) defined global education as an effort to help individual learners see the world as a single and global system and see themselves as a participant in that system. A school that focuses on global education prepares learners to have a worldview for international understanding. Becker emphasised that global education incorporates into the curriculum and educational experiences of each student a knowledge of and empathy for the different cultures of a nation and of the world. Hanvey, as quoted in Burnouf (2004), proposed five dimensions that should be part of global education: perspective consciousness, state-of-the-planet awareness, cross-cultural awareness, and knowledge of global dynamics and an awareness of human choice. Pike and Selby (1995) talked about four dimensions: spatial, temporal, inner and issues. Deardoff (2006) stressed that a global teacher also needs to be interculturally competent. This implies attitudes of openness, respect, curiosity and discovery towards other cultures, sensitivity towards otherness and the recognition of one's own cultural norms and ethnocentricity. Escobido (2017) add to this when he define a global teacher as one that is " a competent teacher who is armed with enough skills, appropriate attitude and universal values to teach…and thinks and acts both locally and globally with worldwide perspectives, right in the communities where he or she is situated" . Global education includes studying human values and beliefs, global systems, problems, history, cross-cultural interaction, and understanding (Merryfield, 1993).

O'Tool (2006) said that in order to prepare student teachers to work in a multicultural context in an increasingly globalised world, they must be taught about both developmental issues and multicultural contexts. That means that economic developmental education and multicultural education are equally important. To educate global teachers, teacher education must therefore incorporate both global and justice dimensions in the education (O'Tool, 2006, p. 99). However, according to Merryfield (2000), while theoretical courses are important, they are not enough to create a global teacher. Lived experience is also

necessary, as "Experience alone does not make a person a multicultural or global educator. It is the interrelationships across identity power and experience that lead to a consciousness of other perspectives and recognition of multiple realities" (Merryfield, 2000, p. 440). This is easier for teachers who themselves belong to underprivileged groups in society. Experiences such as international mobility programmes might help those who belong to the majority population by helping them to change their perspectives and by providing substantial knowledge along with the lived experience of another culture and society (Nunman, 2006).

3. Methodology

This is a qualitative phenomenological long-term effect research. The data of this study were gathered from former student teachers using qualitative methods. To find the former student teachers, we obtained the records that were kept on file on the international practicum program. We sent emails to 30 former student teachers who had taken part in the international practicum program during the period from 2007–2017. We received answers from 18 of them. That gave us a response rate of 60%. All of the respondents were working as teachers in primary schools. Unfortunately, we do not have any information that could help us discuss the skewness of the sample.

We considered the fact that some of the respondents had their experiences in Namibia 10 years ago, while the most recent ones had them just 2 years ago and that this might have some implications for the way in which they answered. While we could not see any systematic connection between the time that had passed and the way that participants answered.

In the questionnaire, we asked the participants open ended questions and focused mainly on professional, personal, intercultural and global dimensions. The questions were as follows:

- How would you describe your personal and professional development as a result of your stay in Namibia?
- Did your stay in Namibia influence your choice to become a teacher?
- How did your stay in Namibia change your view of other cultures and your global awareness?
- How did your stay in Namibia influence your teaching on global and cultural topics?

- Please reflect upon whether your stay in Namibia has made you a more competent teacher in a multicultural classroom.

The material was analysed using general inductive approaches. Each participant's response was analysed based on themes deduced from the literature review, thus the organisation of the material was mainly theoretically derived. The main themes were: 1. Personal and professional growth operationalized as self-esteem, perspective of education and the teacher role and self-efficacy. 2. Gaining a global perspectives, operationalized as new knowledge and broadened perspective of inequality, poverty and injustice. C. Intercultural competence operationalized as ability understand others and to communicate across cultural difference in the classroom. Below, the main findings are presented and structured according to the main following categories. Although these headings are useful for presenting the findings, there were occasional difficulties in organising the findings as the categories overlap. Throughout the presentation, quotations are used to illustrate the respondents' views.

1. Results

1.1. Personal and Professional Growth

All teachers must discover their own roles as teachers. This is a process, and it is obvious that the experience of working as a teacher in Namibia made an impact on this process in the participants. Most of the respondents stated that the stay aided their personal growth, self-esteem and understanding of education in context. Some even claimed that this experience was the reason why they decided to become teachers as they were unsure if it would be the right profession for them despite being third year student teachers.

Personal growth is a complex concept, and it means different things to different people. As examples of personal growth, the respondents mentioned: learning to look after themselves, being patient and having self-understanding. Living away from family and friends can be a frightening and lonely experience; however, it can also provide an opportunity to listen to an inner voice and develop self-understanding, thus discovering new qualities and strengths. Increased self-esteem was an outcome that many participants mentioned because they had learnt how to connect with strangers in an unfamiliar setting, discover how things worked, speak English and live in a different culture. For most, this was a

challenge, but by managing the situation, they found that they could set new goals for themselves and then reach them. This was a new and important personal experience for many of the respondents, and the manner in which it increased self-esteem is illustrated by the following two quotes:

> I am more confident and trust my own judgement. I was the type who stayed in the background and let others lead, but that has changed due to my stay in Namibia.
>
> I learned how to fit into an unfamiliar society and culture. It was different from being on vacation. Working at a school meant that I had to adjust and cooperate with people from another culture. My stay in Namibia was the best period of my life. I have no regrets, and I miss it a lot.

Professional development was one rationale for the institution to send these student teachers to Namibia. Many of the participants claimed that their lived experience in the Namibian schools and with Namibian life in general has helped them to obtain a broader perspective on both education and schools. In the Namibian classroom, they met ethnic diversity, poverty and a lack of resources. The student teachers had never experienced classrooms of more than 30 pupils; in Namibia, classes of 40 to 50 are common. In some classrooms, there were not enough chairs or desks, and a lack of learning materials and books was common. There was no functioning ICT. Teaching in an unfamiliar setting with large classes, language challenges and few resources has made the participants more innovative. In the beginning, they did find it problematic to be without the many kinds of teaching materials available to them in Norwegian schools; however, they later discovered that they could find alternative methods for teaching. Many said that they could teach without textbooks. This not only increased their confidence as teachers but also changed their perspectives on what is required to provide effective teaching. Some discovered that the pupils learned even without sophisticated learning materials being available, and they could handle large classes without a teaching assistant. Some used this experience to better appreciate the small class sizes and abundant learning materials available in Norwegian schools. However, this also provided a substantial knowledge of how different educational opportunities are globally. This is an important result as it related to the idea of global teacher as a social justice agent. One respondent said the following:

> The stay made me sure that I wanted to become a teacher. I had to teach without any technology or learning materials. I had to work hard to plan and create my lessons. I managed, and I knew that I would like to become a teacher.
>
> By teaching in a Namibian school, I developed as a teacher by reflecting on the differences, and I now understand the importance of context for learning.

The typical Namibian teacher conducts a teacher-led, top-down class with little dialogue, differentiation or focus on motivating learners. The teaching style is mostly authoritarian and teacher centred. The students observe one-way communication: the teacher speaks and the pupils listen and answer. This lack of dialogue caused the Norwegian student teachers to question the outcomes of the lessons as they had been taught in their own education that dialogue is a necessity for learning. Furthermore, differentiation and motivation are key aspects of the teaching ideology of Norwegian schools. For some respondents, this experience led them to have to a deeper understanding of the importance of offering special education, inclusion and differentiation.

> I have become a better teacher because I am better at adjusting my teaching to individual learners and the class. I learned to handle very diverse classrooms, diverse when it came to learning ability, language and age. For example, I had to work hard to get the Namibian learners to become active in class; they were not used to speaking up. I now use that experience when I come across the same type of classes in Norway.

In general, the participants expressed that they had increased personal and professional self-efficacy as a result of their practicum in Namibia. For some, the experience changed their professional perspective more than others. For example, one participant stated:

The stay in Namibia showed me how much I liked to be part of an international milieu, and that has changed the course of my professional carrier. I want to work in a multicultural classroom and use what I have learned. For instance, I learned techniques to communicate across cultures.

4.2 Gaining a Global Perspective

A global teacher needs to see the world as a single system and understand their own role according to Backer 1982. In order to gain a global perspective one need knowledge of other countries and cultures. A global perspective is encompassed by two dimensions: a knowledge dimension and a perspective dimension.

Substantial knowledge is a lasting outcome of an international practicum. All of the participants gained knowledge of a developing subtropical African country. For example, their first-hand experience of poverty made it a concrete concept. They experienced how poverty looks, smells and sounds. Moreover, they have seen many of the consequences of poverty. They expressed feeling helpless when coming to understand the deep poverty in which many of their pupils lived and its consequences for their education. For example, some students could only attend school occasionally because they had to work and look after younger siblings as both parents had died and they lived alone in the slums.

> A substantial knowledge of other cultures is valuable for a teacher. I am a better teacher of global issues because I have lived and worked with people who live under much different material conditions than we do in Norway. As a teacher, it is important to be good in your subject and have experience with many different factors, and the fact that I had this experience has made me a better teacher of global and multicultural subjects. My travels have influenced my teaching—what I teach and how I teach and which values I convey.

However, participants also found that there were "no automatic connections between happiness and having many things", as one respondent said. They observed how people could manage with few material possessions, little money or other items, while we in Norway seem to need very many things. The stay in Namibia made the participants feel and understand the differences between Norway and an African country. This added substantially to their knowledge of how different standard of living could be across the world.

Many of the participants said that the substantial knowledge gained from their experience in Namibia has influenced their teaching. Overall, it has had an influence on their choice of themes, teaching international and global concepts more often than they would have without having lived Namibia. In addition, they have many concrete examples from Namibia that they can use to illuminate their lessons which made their teaching more authentic:

> I use my personal experience and stories from Namibia when teaching about poverty, inequality and global issues. My learners like that I share this with them and include it in my teaching. For instance, I can talk about secondary poverty and tell them about how some people in Namibia seemed to have strange priorities (when it came to how to spend money). The stay has made an influence on all of my teaching; I focus on global south and global north in my teaching and include aspects of lifelong learning and SDGs. These are all subjects that are also important in Norwegian classrooms.

It is also typical for the participants to follow international news more closely than before, especially the news from Africa. Some have also become more critical of the news from Africa. They have observed how the media portrays events from a Western point of view, and because we have so little knowledge of much of the world, it is difficult to know what is true. Overall, the stay in Namibia made the participants more globally oriented as teachers and developed a more critical approach. The stay in Namibia has not only given them substantial knowledge about Namibia, but in addition, many have continued to add new knowledge and global perspectives on their own.

According to Mesirow (2000), a change in perspectives is difficult without new experiences. One point that seems to have made a lasting impact on the teachers is the magnitude of inequality. While there are poor families and inequality in Norway, Norwegian poverty and inequality cannot compare to that found in other parts of the world. Living in Namibia changed the student teachers' perspectives on the concepts of inequality and poverty. In Norway, the social security system ensures that hunger does not exist and that people have decent homes and enough money to cover basic needs. This is not a global situation, and the teachers saw this for the first time in Namibia. The following is a telling quote:

> Inequality in a poor country is so great; some people lived in big houses with a swimming pool, while others lived in container houses in the slums and often shared them with other families. The magnitude of inequality made me see that the inequality in Norway is a different matter altogether.

Many of the participants gained a personal experience of injustice in Namibia. Namibia has a history of apartheid. Until 1990, Namibia was governed as province of South Africa, and this meant that different ethnic groups were

segregated and followed white minority rule. Because they were white and had money, our student teachers found that they belonged to a privileged class. They were invited to places where their black colleagues were not, and they experienced inequality and racism and saw how unfair the world could be. Their experience of having the advantages of being white meant that they could socialise with both white and black people, rich and poor, providing a lasting effect and a knowledge perspective. Moreover, this experience has enabled some of the participants to include a justice dimension in their lessons. Many also received a more complex understanding of the factors that hamper economic development. They saw that internal factors, such as values and culture, not only hamper development, but there are also external factors that must be taken into consideration.

4.3 Intercultural Competence

What is the nature of intercultural competence? We base our understanding on the definition from two of the most influential academics in the field - Bennet (2012) and Deardorff (2004). Bennet's definition "refers to the acquisition of generalizable intercultural competence: that is, competence that can be applied to dealing with cross-cultural contact in general, not just skills useful for dealing with a particular other culture" (Bennet, 2012). Deardorff (2004) highlights that most of the definitions of intercultural competence include more than knowledge of other cultures, since knowledge alone is not enough to constitute intercultural competence. Intercultural competence also involves the development of one's skills and attitudes in successfully interacting with persons of diverse backgrounds. Based on these two definitions and inspired by Hylland Eriksen (2015) we in the present paper will understand intercultural competence as the ability to communicate and collaborate with people whose attitudes, values, skills and knowledge are significantly different from their own.

> I am a better teacher in a multicultural classroom. I am sensitive to cultural differences, and that influences my teaching. I try to reach out to immigrant learners and have an understanding of how cultural differences might lead to a misunderstanding. I have a first-hand understanding of the feelings of not being understood. Yes, I can feel it when I discuss things with other teachers. I bring in other perspectives, and often I am better at understanding the parents of

> migrant learners. I can see why it is not natural for them to come to parent-teacher meetings or follow up with homework. It is not what they are accustomed to, and some are illiterate. I have developed an empathy and understanding of the situations of immigrant families when they encounter the Norwegian school because I experienced the life that they had before, and I learned how difficult it is to be taught in a language different from your first language. I use this experience when I teach minority learners in Norwegian and social science.

Most of the participants claimed that they had become better qualified to teach in a multicultural and multilingual classroom due to their experience and knowledge gained from Namibia. Their stay opened their minds to differences that might exist between cultures and people. Overall, they broadened their worldview and increased their ability to communicate with people from other cultures.

It is the experience of being the one who stands out, being different and not understanding the rules, culture or language that has led to this increased empathy and willingness to attempt to understand and communicate across cultural differences. Being 'the other' was an experience that made them value the ability to speak, read or watch television in their own language, eat Norwegian food and in general, understand the rules and values of a society. This lived experience helped most teachers to better understand the difficulties that new immigrants face in Norway. The participants could more easily see how immigrant children face a disadvantaged situation in Norwegian classrooms because of both language and cultural differences. The student teachers experienced values and attitudes different from their own and had to deal with ethical dilemmas, for example being a foreign guest in a classroom and being unable to intervene when a teacher administered corporal punishment. Most of the participants said that they felt more competent in understanding and communicating with people from other cultures because of their stay in Namibia. They experienced how very different cultures and people can be but found that people can also be very much alike. The quote below sums this up nicely:

> I am a better listener, more interested in learning from others and see the importance of immigrants being valued for their culture and language and the people they are. I learned that from my stay in Africa and from the people I met. The people that helped us, the people that stole from us, those who believed that white people were ATMs and

> the people who opened their homes to us. I learned how it felt to be an outsider not understanding the language, and I experienced being a minority person who was very much welcomed—that was a great feeling that I hope to give to my immigrant learners and other newcomers to my country.

The practicum in Namibia changed how many of the teachers viewed and valued other cultures and ways of life. In general, most of them became positive towards and more interested in other cultures. Many have become interested in learning from foreigners and look upon themselves as people that are more tolerant. Some said that their increased understanding and respect for otherness/differences between learners has led to a general interest and respect for diversity.

Perhaps the most important point they learned was to respect others people's ways of living and to acknowledge the value of different perspectives. For example, one participant learned that the Norwegian way of living, culture and norms are not ideals for all. Many people like their own lives and are skeptical towards our way of living. In this teacher's words "it is natural to be ethnocentric—that does not make you a bad person, but remember, the person you are talking to is probably ethnocentric too".

Although the great majority of the participants claimed that their stay in Namibia has made them more open and sensitive towards other cultures and norms, this was not without exception. One teacher claimed to be unsure if the stay had had any impact on his intercultural competence. He said that it was hard to tell if the stay or the new understanding of Namibian culture would be of any value in a multicultural classroom. He said that, while he might have a deeper understanding of other cultures, he could not tell if this understanding was of value as no learners are the same and they all come from many different cultures.

2. Conclusion

For most of the participants, the period abroad in another culture has brought them benefits as teachers in the Norwegian classroom. The international practicum seems to stand out as a special international experience that is distinct from other forms of overseas travel in which some of the respondents have also participated. Personal growth is one of the major positive outcomes.

When it comes to professional development, there were many benefits. Substantial knowledge about the world is one important outcome. Another is a broader perspective and understanding of the world. Increased interest in international news, especially from Africa, is also important, and significantly, many participants have become more critical of the news being reported from Africa. The lived experience from Namibia has also helped many of the participants to become more interculturally competent. An important outcome of their stays in Namibia has been that the teachers feel more competent in teaching diverse classrooms. Due to their greater knowledge and interest in global issues, some participants said that they have placed an emphasis on this in their teaching.

Have these student teachers become global teachers due to their experiences in Namibia? As mentioned earlier, Hanvey proposed five dimensions to global education: perspective consciousness, state-of-the-planet awareness, cross-cultural awareness, knowledge of global dynamics and awareness of human choice.

From our data alone, we cannot conclude that our participants have developed the skills and perspective that a global teacher should have. On the one hand, most of them reported perspective consciousness, increased state-of-the-planet knowledge and cross-cultural awareness. This may imply that they have become more globally oriented as teachers and can prepare learners with a worldview of international understanding. Thus, the teachers who have been in this international practicum programme have increased their competence for teaching in diverse classrooms and with a global perspective. This is not surprising. It is in accordance with what Merryfield (2000) said might be the outcome of international teaching experiences. She said that an experience like an international mobility programme can help those belonging to a majority population change their perspectives by giving them substantial knowledge as well as the lived experience of another culture and society. On the other hand, we do not know the content and perspective of their teaching. They report that they have observed poverty and injustice and have increased their worldview and this have a bearing of what they teach. Furthermore, in their answer they show empathy with the poor and underprivileged that they met in Namibia. Whether or not this means that they have developed an increased understanding of the structures that create underdevelopment, poverty and injustice globally we have little information. In addition, we do not know if their teaching purposely questioning stereotyping of others and add to the pupils understanding of the

complexity of cultures, conflicts and global issues and understanding of global interdependence.

The findings have some implication for teacher education. Sending student teachers for international practicum to the Global South is not enough to develop global teachers. It is important how the institution prepare, follow up and work with the participant when they come home. In their preparation course in is necessary to include intercultural studies, but equally important is development studies, that is studies of economic development theories, World system theories, poverty and inequality. Our argument is supported by Leeman & Ledoux (2003, 2005), who maintain that conscious intercultural and global competence can only be developed when experience is coupled with knowledge and reflection.

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Investigating prospective science and mathematics teachers' meanings for and representations of functions: an international study

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Abstract

The concept of a *function* is crucial in both mathematics and science education. Appropriate teaching of the concept is therefore very important, and an understanding of the knowledge of functions possessed by prospective teachers of science and mathematics is highly desirable. The present study was instigated by the Association for Teacher Education in Europe's Research and Development Community (RDC) on Science and Mathematics Education in order to explore this knowledge across different countries. Using theoretical frameworks provided by research on teacher knowledge and representations in mathematics and science education, the study is investigating meanings that prospective teachers give for the term "function" and representations that they associate with it. An instrument was adapted from a previous RDC study (on ratio). For the initial phase, reported here, research team members in Portugal, Ireland and the Netherlands collected data from opportunity samples at their own institutions, focusing on prospective mathematics teachers. Analysis of the responses (N=145) started with team

members examining their own data; they listed themes, guided by curricular traditions in their own countries as well as by research on knowledge of functions. Lists were then shared in order to identify commonalities and contrasts. The data reflected meanings and representations involving correspondence/dependence relationships and also those based the idea of a "machine"/formula/rule; the former were most prominent in the Portuguese data and least in the Dutch, in line with national curricula. The findings suggest that, in the ongoing study, the instrument will provide useful information for teacher educators.

Keywords: function, representation of functions, prospective teachers, curriculum

1. Introduction

The importance of teachers' – and hence prospective teachers' – knowledge of their subjects, especially in a form appropriate for teaching, has been well established by research ongoing since the 1980s. For developing students' understanding of individual topics, especially in mathematics, the use of multiple representations has emerged over the same period as a key area. Together, these fields of research provide a useful theoretical framework for investigations.

One such investigation is the study initiated in 2018 at the Annual Conference of the Association for Teacher Education in Europe (ATEE) by its Research and Development Community (RDC) "Science and Mathematics Education". The study focuses on the concept of a function – a major topic in mathematics education, and important also for science – and is intended to examine the knowledge possessed by *prospective teachers* of mathematics and science (that is, students in preservice teacher education programmes involving mathematics and science, and also those attending relevant courses or modules that attract students with an interest in teaching). The aims of the study are to address the following research questions:

a) What meanings do prospective teachers for primary and secondary levels, attending selected institutions in different countries, give to the term "function"?
b) What multiple representations do these prospective teachers associate with the term "function"?

c) What implications do the prospective teachers' descriptive meanings and representations have for teacher education courses with regard to functions?

An instrument intended to elicit the meanings and representations was adapted from one used in a previous RDC study (on ratio, another topic spanning mathematics and science). Originally written in English, it was translated into Portuguese, Dutch and German to facilitate use by RDC members from different countries. For a first exploration, the focus was on prospective teachers of mathematics. Members of the RDC from Portugal, the Netherlands and Ireland administered the instrument to selected groups of prospective mathematics teachers in institutions in their own countries. The data were analysed, first with RDC members considering their own data sets and then with their insights being combined. By using this approach, the RDC is seeking to find possible commonalities or contrasts that may reflect differing understandings of functions within different mathematical traditions, national curricula or contexts. These may illuminate a range of approaches to teaching and learning about functions and also highlight aspects of knowledge that may need to be addressed with prospective teachers.

In order to illustrate the work involved in the exploratory phase of the project, the curriculum with regard to functions and the sample data analysis for one country – Portugal – are presented in some detail. Those for Ireland and the Netherlands are described more briefly, with a focus on similarities and contrasts. While findings from the opportunity samples may not generalize, they may indicate the potential of the instrument to reveal useful information for teacher educators.

In section 2 of the paper, a review of literature is provided, addressing the notion of function and its occurrence in the mathematics curricula of the three countries considered in this paper, and also the use of representations in the teaching of functions. Section 3 describes the methodology for the study, in particular during its initial phase. Results for this phase are presented in section 4, with discussion and conclusions being provided in section 5.

2. Literature Review

Given the objective of this work, the literature review focuses on the notion of function (section 2.1) and its different representations in the teaching of mathematics (section 2.2).

2.1. The notion of function in mathematics curricula

The complexity of the construction of the notion of function causes many students and prospective teachers to manifest difficulties in expressing its meaning clearly (Martinho & Viseu, 2019; Viseu, Martins, & Rocha, 2019). A study by Vinner and Dreyfus (1989) shows that college students in a calculus course were often not able to apply the definition of a function correctly, even when they could give a correct explanation of it. Breidenbach, Dubinsky, Hawks, and Nichols (1992) point out that "college students, even those who have taken a fair number of mathematics courses, do not have much understanding of the function concept" (p. 247), confirming that this is a complex concept to understand and that, consequently, its conceptual development requires a longer period of time. According to Hansson (2004), the concept should be introduced dynamically as a kind of relationship, correspondence, or covariation, rather than through the static notion of a set of ordered pairs.

To set the study of functions in context, relevant features of the three education systems and curricula are described. As in many of the counties in the world, the *Portuguese* education system comprises twelve years of mandatory study to grant access to higher education levels. Of these years, the first nine correspond to basic education and the last three to secondary education. Basic education consists of three cycles: the first one, lasting four years – grades 1 to 4 – is also known as the primary school; the second cycle lasts two years – grades 5 to 6 – and the third one three years – grades 7 to 9. For all three cycles, the mathematics syllabus is the same for all students. Until the end of the third cycle, it is structured around the following themes: Numbers and Operations, Geometry and Measurement, Algebra, and Organization and Data Processing (Ministério da Educação e Ciência, 2013). Beyond their formative purpose, along with the acquisition of knowledge and procedures, the study of these themes aims at promoting the development of skills and attitudes. Capacities to be developed include problem solving, communication, and reasoning. As the educational process evolves, students' cognitive activities also gradually shift attention from concrete situations to more abstract ones. An example of activities on concrete situations are the arithmetic operations, within the theme Numbers and Operations, which can be translated into manipulatives. The topic "Function", within the Algebra theme, on the other hand requires activities involving abstract situations.

The notion of a function acquires an abstract nature as it results from a mental construction (Evangelidou, Spyrou, Elia, & Gagatsis, 2004). Such a construction, which in the Portuguese Mathematics syllabus is placed in the third cycle of basic education, highlights the relevance of mathematical communication, namely of a number of linguistic aspects that help students to build the correct intuitions. This includes, for example, the linguistic ability to distinguish functions from general correspondences, or to identify object, image, domain, range, and contradiction, as well as independent and dependent variables (Martinho & Viseu, 2019). In order to emphasize the meaning of this terminology, different representations of functions can be considered: for example arrow diagrams, tables and Cartesian graphs. The acquisition of such terminology plays a crucial role in the introduction of the notion of a linear function and, consequently, of a direct proportionality function.

Subsequently, the inverse proportionality function is studied through its different representations (tabular, analytical and graphical) and the quadratic function through the identification of the curve representing functions of type $f(x) = ax^2$ (with $a \neq 0$) and the solution set for the equation $f(x) = ax^2 + bx + c = 0$ (with $a \neq 0$) as the intersection of the parabola, $y = ax^2$, and a straight line, $y = -bx - c$.

In the transition to secondary education, the knowledge acquired in the third cycle acts as a prerequisite to the study of function composition and the inverse of a bijective function, as well as to identifying intervals of monotonic growth and the extremes of real-valued functions of real variables (Ministério da Educação e Ciência, 2013). The study of functions broadens: students are introduced to trigonometric functions, the Heine limits of real functions with real variables, derivatives of such functions and their applications. Finally, the study of limits and continuity of real-valued functions of a real variable is carried out and the study of derivatives of such functions deepened.

In *Ireland*, there are 14 years of school education, eight for primary school and six for post-primary school. The post-primary curriculum has two cycles, junior (for students typically aged 12-15) and senior (for students aged about 15 to 18); the mathematics courses contain strands on Number, Algebra, Geometry and Trigonometry, Statistics and Probability, and Functions (the latter including calculus in the senior cycle). Following the most recent revision, implemented in autumn 2018, the Functions strand in the junior cycle has been merged with the Algebra strand, reflecting intentions with regard to how functions might be taught (Department of Education and Skills, 2017). Similarly to the case for

Portugal, the school curricula address overarching key skills, and mathematics and other curricula move from a more concrete to a more abstract focus in the higher grades.

Prior to the 1960s, Irish students encountered functions determined by algebraic or trigonometric expressions, and typically represented by graphs. Consideration of limits underpinned the introduction of calculus for the more advanced students. From the time of "modern mathematics" in the 1960s, students were introduced to functions as special relations, hence as sets of couples displaying the uniqueness property (each first element being associated with just one second element), and the terminology of domain, codomain and range was emphasised. However, this approach coexisted with the more traditional one for dealing with equations, coordinate geometry, graphs and calculus. The two conceptions have continued, with varying degrees of prominence, to the present day. The junior cycle curriculum introduced from 2008 indicates that students should "engage with the concept of a function (that which involves a set of inputs, a set of possible outputs and a rule that assigns one output to each input)" (Department of Education and Skills, 2013, p. 30). The revised version currently being implemented stresses that learners should "represent and interpret functions in different ways – graphically…, diagrammatically, in words, and algebraically – using the language and notation of functions (domain, range, co-domain, f(x) = , f :x ↦, and y =)" (Department of Education and Skills, 2017, p. 19).

The *Netherlands* provides up to 14 years of schooling. The number of different schooltypes in the system, and the tradition of relative curricular freedom, mean that it is hard to summarise the mathematical provision succinctly. Of more relevance here than the year-by-year details is the tradition of Realistic Mathematics Education. While both Portugal and Ireland adopted "modern" (hence, notably abstract and formal) curricula in the 1960s/1970s, the Netherlands introduced an approach that focused on being "real to the students," typically involving the solution of problems set in engaging contexts. With regard to functions, such a setting is suitable for a focus on the dynamic rather than the static (set-theoretic, "modern") conception, in line with the work of Hansson (2004), cited above. The curriculum duly reflects the approach (Creative Commons, n.d.).

2.2. Representations in the teaching of functions

Current methodological recommendations for the study of functions emphasise the use of different representations as a crucial element of the learning process (Chazan & Yerushalmy, 2003; National Council of Teachers of Mathematics, 2000, 2014), as each of them highlights a complementary aspect.

Tabular representation. This representation, also called numerical, depicts the function as a table relating objects and images. Therefore, it leads to the discovery of the general relationship underlying the function at hand. Checking that it is really a function requires analysis of the structure of the relationship represented in the table, to confirm that each object has a unique image. For Brown and Mehilos (2010), this representation promotes the passage from concrete to abstract, giving meaning to variables and algebraic expressions.

Graphical representation. This representation makes explicit the points corresponding to (object, image)-coordinates in a Cartesian plane. Therefore, it provides a quick way to detect typical properties of functions, such as zeros, sign change, and monotonicity. For Friedlander and Tabach (2001), the graphical representation is intuitive and appealing due to its visual character.

Analytical representation. In addition to the sets acting as the function's domain and range, this representation expresses the relationship between objects and image through an analytical expression. It paves the way to the use of algebraic laws to transform the analytical expression in the study of the function properties. Friedlander and Tabach (2001) consider this representation an accurate and general way to make explicit the underlying formal patterns and models. Moreover, algebraic manipulations are often the only way to justify general statements about the behaviour of a function.

The complementarity between aspects revealed by different representations of function entails the need for students to explore all of them (Santos & Barbosa, 2016). Nachlieli and Tabach (2012) argue that, in practice, such a multi-perspective view is not always present in the teaching process. Often only one representation is used, and, when more than one is considered, the way they relate to each other is not discussed. Tripathi (2008) argues that limiting the study of the notion of function to a single representation is "approach[ing] the concept blindfolded" (p. 438).

This assumption is the basis of some studies conducted in the field of mathematical education. For example, Evangelidou et al. (2004) carried out a study with prospective teachers, predominantly for primary education, seeking to understand how functions are interpreted in terms of their conceptual

meaning, and recognized in multiple representations. The study highlighted three trends in the prospective teachers' notion of a function. Most of them identify the notion of a function with the more specific concept of a "one-to-one function". Although injective functions often arise in practice, this incorrect identification becomes a strong obstacle to understanding function as a broader concept. The second trend identifies a function with an analytical relationship between two variables. The third trend connects the notion of a function with a diagram type or a Cartesian graph.

The ways in which the notion of a function is conceptualized can be also be framed in terms of image (mental construction that represents the cognitive structure associated with the concept) and concept (Vinner & Dreyfus, 1989; Tall & Vinner, 1981). In particular, Vinner and Dreyfus (1989) identified different categories of definitions and conceptual images. Drawing on their work, Viirman, Attorps, and Tossavainen (2010) used the following classification:

Correspondence/dependency relationship. A function is any match or dependency relationship between two sets that assigns each element in the first set to exactly one element in the other.

Machine. A function is a "machine", i.e. one or more operations that transform variables into new variables. In this case, no explicit mention of domain and range is made.

Rule/formula. A function is a rule, a formula, or an algebraic expression. Compared to the second category, the difference is that a rule typically entails some form of regular behaviour, whereas the "machine" could perform totally different transformations of different elements.

Representation. The function is identified with one of its representations.

Meaningless. A meaningless answer or no answer.

For Vinner and Dreyfus (1989), students' common images of the concept of a function have direct implications for teaching, since they can be used as a starting point to the construction of the concept itself.

3. Methodology

The research questions for the study are listed in the Introduction. To address them, the RDC team developed an instrument and used it to collect data from groups in institutions in three countries, as described below.

3.1. Research instrument and administration

Since the international study involves groups speaking different languages, the RDC chose to use a short written questionnaire (hence, obviating the difficulties that might have arisen in sharing data from extended interviews). The instrument was based on one used in a similar RDC study, on the concept of ratio (Berenson, Oldham, Price, & Leite, 2013). It contained four open questions – one in two parts – allowing participants to describe their knowledge of the meanings and representations of ratio. The equivalent questions (or items) for the functions study are as follows:

1. What does the term "function" mean to you?

2a. When do you yourself use functions?

2b. Who else uses functions, and when do they use them?

3. Which mathematical symbol(s) do you use to represent functions? You may write expressions that include the symbols, rather than just the symbols themselves.

4. Show how you would explain the concept of "function" (not using words only!). Give a few examples if you can. Present your ideas here and/or overleaf as you wish.

Question 2 involves awareness of applications; question 4 allows participants to demonstrate some mathematical knowledge for teaching (Ball, Thames, & Phelps, 2008). The four questions were set out on a single page of A4 paper, also providing introductory and classifying material, as shown in Figure 1.

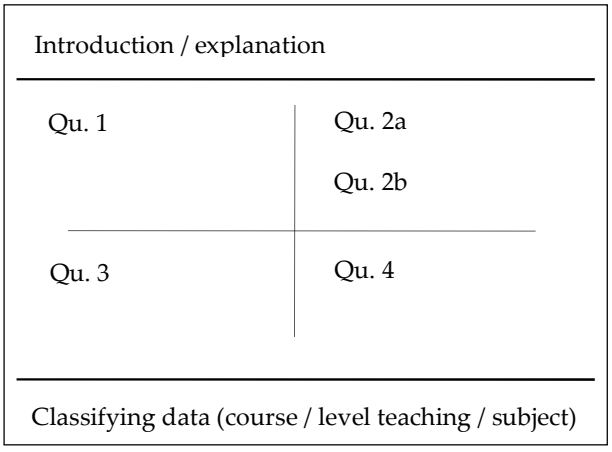

Figure 1 - Layout of the questionnaire

It was intended that data collection could be completed in about fifteen minutes, say at the end of a class period, making minimal demands on teaching time. As indicated above, the instrument was localised for use in different countries and institutions, with the original English-language version being translated into Dutch, German and Portuguese, and the classifying material (identifying the participating class groups) being formulated appropriately for each site.

For the exploratory phase of the study, appropriate ethical clearance was obtained for participation at institutions in Portugal, the Netherlands and Ireland. (Unfortunately, the team member from the USA, who had hoped to collect data, did not receive ethical clearance in time.) The instrument was administered to opportunity samples in these institutions during the period from autumn 2018 to spring 2019, at times that suited the schedules of the participating groups. The sets of data from each country were subjected to content analysis by the RDC members responsible for collecting them. Tentative classifications and themes were identified, using categories suggested by the data but also influenced by local curricular issues and literature on functions and representations, and the data were coded accordingly. This resulted in some differences in classification and interpretation, which have yet to be resolved. In this paper, the Portuguese codes are given priority, and the Irish and Dutch data are tentatively examined using the Portuguese categories where possible. Those categories are as follows:

Question 1: Correspondence/Dependency relationship; Machine; Formula/rule.

Question 2a: School context; Out-of-school context; School and out-of-school context.

Question 2b: Teachers and students; Specific professions; Any professional context.

Question 3: Isolated terminology; Analytical expression; Arrow diagram; Multiple representations.

Question 4: Everyday language; Algebraic expressions; Arrow diagram; Cartesian graph; Multiple representations.

3.2. Participants

The *Portuguese* study included 87 prospective teachers organized into three groups according to the year they attended. Group A consisted of 29 students from the first year of the bachelor's degree in basic education (S1 to S29); Group

B consisted of 40 students from the third year of the bachelor's degree in basic education (S30 to S69); Group C consisted of 18 students from the second year of the master's degree in teaching primary school and Mathematics and Natural Sciences at basic school (S70 to S87). The codification, from S1 to S87, followed the order of the students of each grade considered.

The *Irish* participants consisted of two groups in one university: 18 undergraduate mathematicians taking a Mathematics Education module that involves them in helping students in school or other classrooms (hence being considered as prospective mathematics teachers) and four preservice teachers of mathematics (in the first year of their two-year professional master's programme leading to national accreditation). The unusually small number in the preservice course obviates analysis of the two groups separately. The 22 students are coded as S88 to S109, with the undergraduate group being listed first.

The *Dutch* cohort consisted of 36 preservice mathematics teachers in their first year of teacher education. They are coded S110 to S145.

4. Results

As indicated above, the Portuguese results are given priority. Selected findings from Ireland and the Netherlands are then compared and contrasted with them.

4.1. Portuguese results

Regardless of the cycle of study in which they are enrolled, most future teachers in the Portuguese sample relate the notion of function to a correspondence between elements of two sets, or to the dependence of values of one variable on the values of another (72%) (Table 1).

Table 1. - Frequency of answers from different Portuguese groups to question 1

Meaning of the term function	Group A	Group B	Group C	Total
Correspondence/Dependency relationship	24	29	10	63
Machine	1	0	2	3
Formula/rule	0	1	1	2
Meaningless	3	9	5	17
No reply	1	1	0	2

Total	29	40	18	87

For some students, the existence of a correspondence between two sets is the only requirement they make explicit as characterising a function, as exemplified by the following answers: "a relationship between two sets" (S9); "Relates to sets, images and objects" (S11); "a relationship between variables" (S76). Such a conception translates into a fragile definition, which mixes up functional and non-functional correspondences.

The correspondence between elements of two sets is made more explicit in the answers mentioning a dependence between the values of variable, as illustrated for example in: "function means a transformation of an x by a y. When we have a dependent variable and an independent variable" (S80); "A function implies the existence of two variables (x, y). By organizing the regular data in a graph, we can predict the values of x or y, knowing other variables" (S55). It should be noted that the last answer was given by a student who was previously exposed to modelling tasks to search the curve that best fits points from a particular experience.

A few students, seven out of the 87, explain in their responses that a function is a relationship that forces each object to have one and only one image, as exemplified by the following answer: "A function is when one element of the starting set corresponds to one and only one element of the target set" (S52).

Some other students lean toward the operational perspective classified as a "machine" by Viirman et al. (2010). Examples are: "A function is a mathematical method used to find an unknown value" (S23); "A function is something that allows us to determine and correspond to an x or the opposite in a particular case" (S79); and again "Function means a transformation of an x by a y. When we have a dependent variable and an independent variable" (S80). Such responses somehow resort to the transformation metaphor, which is sometimes claimed to capture the uniqueness of image in a functional correspondence.

The association of a function with a rule or formula occurs only in the responses of two students: "It consists of an expression with at least 2 unknowns, where one can verify the relationship between them"; "a function is an expression that relates two variables, thus one being a dependent variable of another" (S76). Such answers reveal a symbolic conception of the notion of a function.

Along with the meaning students give to the notion of a function, situations in which they perceive that they use functions are investigated (question 2a). Most answers (59%) favour the school context. Only a few responses highlight their use in out-of-school contexts (20%) or in both school and out-of-school contexts (18%) (Table 2).

Table 2. - Frequency of answers from different Portuguese groups to question 2a

When using functions (by context)	Group A	Group B	Group C	Total
School context	11	29	11	51
Out-of-school context	9	4	4	17
School and out-of-school context	7	7	2	16
Meaningless	1	0	1	2
No reply	1	0	0	1
Total	29	40	18	87

The use of functions in the school context emerges within activities proposed by the teacher – "I only use functions when asked so by teachers" (S47) – or in the context of academic activities, i.e. when studying "school or university" subjects (S18). A curious answer stresses the fundamental role of functions in all mathematical activities: "mathematics as a way of getting a relationship between two sets" (S3). Some students argue that functions can be used in any context, such as "in mathematics classes and sometimes in everyday life" (S27).

With respect to the question "Who else uses functions, and when?", question 2b, responses highlight in a similar way academic situations, specific professional contexts, and even the professional context in a broad sense (Table 3).

Table 3. - Frequency of answers from different Portuguese groups to question 2b

Who uses functions (by context)	Group A	Group B	Group C	Total
Academic context	7	13	4	24
Specific professions (engineers, nurses, etc.)	7	12	8	27
Any professional context	9	11	6	26
Meaningless	1	2	0	3

No reply	5	2	0	7
Total	29	40	18	87

Within the academic context, students identify as typical users of functions "mathematicians and learners" (S1), the "teachers in the class" (S43) or the "mathematicians and students of mathematics, as they are presented with a diverse number of problems in which you have to decipher or apply functions" (S53).

For professional contexts, there are students who consider that those who use functions are "traders and their buyers" (S3), "architects to carry out projects" (S21), the people "who work with money and quantities" (S15), and "Taxi drivers when calculating the total value of the fare; … any seller who wants to know the full value of a purchase" (S30). Some participants combined both academic and everyday contexts, as in: "mathematicians mainly, but everybody uses them, on a daily basis, to solve mathematical problems, to calculate unknowns that arise in everyday life" (S31).

Concerning the representation of functions, students were asked about which mathematical symbols they usually use. Their answers highlight the use of isolated terminology and analytical expressions (Table 4). Examples of the former include "x, y, ( )" (S2); "A lowercase letter, ex. f" (S6); or "f to represent a function and we have an image and an object" (S24).

Table 4. - Frequency of answers from different Portuguese groups to question 3

Symbols used to represent functions	Group A	Group B	Group C	Total
Isolated terminology	12	22	5	39
Analytical expression	11	11	8	30
Arrow diagram	2	4	0	6
Multiple representations	0	1	3	4
Meaningless	4	1	2	7
No reply	0	1	0	1
Total	29	40	18	87

In the answers mentioning the use of analytical expressions, students tend to resort to the usual textbook symbolism, e.g. "x and $f(x)$, for example, $f(x) = 2x^2$ or $g(x) = 2x + 1$"(S27); "$Y = mx + a$; $y = x^2 + a$"(S53).

Finally, the last question asked students to indicate how they would explain the concept of a function. Most of them claim to resort to the use of an "Arrow diagram" (39%) or to multiple representations (16%) (Table 5).

Table 5. - Frequency of answers from different Portuguese groups to question 4

Explanation of the function concept	Group A	Group B	Group C	Total
Everyday language	3	3	4	10
Algebraic expressions	1	4	0	5
Arrow diagram	12	18	4	34
Cartesian graph	3	2	4	9
Multiple representations	5	4	5	14
Meaningless	5	9	1	15
Total	29	40	18	87

A few students would resort to "everyday language" (12%), as illustrated by the following answer: "Something that is associated with something for a particular purpose. For example, in 2 weeks I complete 2 homeworks, in 4 weeks I complete 4. Another example: My brother is 6 years old, I am 9. When he will be 18, I will be 21" (S2).

In the illustration of representations to highlight ways of explaining the concept of a function, there are students who refer simultaneously to an "arrow diagram" and a "Cartesian graph", as exemplified by the answer of the student S20 depicted in Figure 2.

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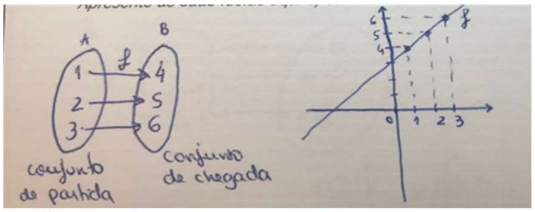

Figure 2. - Reply (S20) to question 4

The student starts from an example presented through an arrow diagram with a discrete set, and then states that "To explain the concept of a function, I would start by drawing two sets and match one to the other in terms of one and only one term. Then I would draw a graph and explain that the function is the line connecting the intersection points of x and y" (S44). This answer, like many others, reveals students' weakness in mastering the concept of a function. It should be added that the majority of answers to the question under consideration are based on examples only. Few students were concerned with providing any additional explanation.

A final point can be made about the Portuguese data; the patterns across the three participating groups are very similar. Analysis of differences in detail is outside the scope of the paper.

4.2. Irish results

Analysis of the Irish data was guided initially by the way in which responses reflected the curricular trends outlined in section 2.1 as well as the literature described in section 2.2. The Irish presentation of results for questions 1, 3 and 4 is available elsewhere in this volume (Oldham & Prendergast, 2020). For the present paper, therefore, most of the data was recoded using the Portuguese categories – though further work would be needed, with cross-coding between Irish and Portuguese team members, before comparability could be firmly established. A feature of the Irish data is that many students gave multiple responses (more than one example in a single category – not reflected in the tables below – or responses in more than one category), so the total number of responses can be more than 22.

The frequencies of occurrence of the Portuguese categories in the Irish responses to question 1 are shown in Table 6. Not all responses fitted easily into the

classification, or at least into the one by Viirman et al. (2010) on which it is based; for instance, the (explicit or tacit) "machine" analogy was presented along with mention of domain and range (see section 2.2 above). This perhaps reflects the intertwining of different function concepts in the Irish curriculum. Some participants gave a formal definition, for example stating that a function is "a subset, for given [sets] A and B, of A×B such that [the uniqueness property holds]" (S88). Others appear to have taken literally the query regarding what function meant to them, and provided a looser or more personal statement; an instance is: "A function, for me, is a program which converts an input (or set of inputs) into an output (or outputs)" (S102). In contrast to the Portuguese case, most responses were in the machine/formula/rule categories, and seven of the students (almost one-third) mentioned the uniqueness property.

Table 6. - Frequency of answers from Irish participants to question 1

Meaning of the term function	Total
Correspondence/Dependency relationship	9
Machine	11
Formula/rule	4
Meaningless/other	1
No reply	0
Total	25

In responding to question 2, most students indicated where they would use functions (hence providing a context), but three – perhaps focusing on the word "when" – identified a task without giving such a context. An example is "When I want to see the outcome of a certain event which requires inputs" (S96). The classification is presented in Table 7.

Table 7. - Frequency of answers from Irish participants to question 2a

When using functions (by context)	Total
School/college/academic context only	9
Out-of-school context only	2
School and out-of-school context	7

No context given	3
Meaningless/other	1
No reply	0
Total	22

For question 2b, an explicit category has been added in Table 8, covering responses that highlighted the broad applicability of functions especially in everyday life (compare S31 above). For example, S90 wrote "… and also in everyday life, people use functions in some simple form," and S101 stated "Everyone, whether they realise it or not."

Table 8. - Frequency of answers from Irish participants to question 2b

Who uses functions (by context)	Total
Academic context	4
Specific professions (engineers, nurses, etc.)	18
Any professional context	6
Everyone/everyday life	7
Meaningless	0
No reply	0
Total	35

The original Irish coding for question 3 specifically reflected the notation used in the Irish curriculum, as described in section 2.1 above (see Oldham & Prendergast (2020)). It was not considered useful to recode the data for presentation here. For question 4, however, the Irish categories are sufficiently close to the Portuguese; the results are presented in analogous form in Table 9.

Table 9. - Frequency of answers from Irish participants to question 4

Explanation of the function concept	Total
Everyday language	15
Algebraic expressions/symbols	12

Arrow diagrams	6
Input/function-box/output diagrams or pictures and variants	12
Cartesian graph	2
Meaningless	0
Total	47

Again, in contrast with the Portuguese responses, over half of the students (12 out of 22) indicated that they would provide a machine-type explanation, hence focusing on a dynamic rather than a set-theoretic approach; just six (fewer than one-third) used arrow diagrams. Everyday language and symbols generally appeared alongside another type of response, and only five students gave a single example. Responses similar to the one in Figure 2 above are included in the Irish paper (Oldham & Prendergast, 2020).

A final point here is that the Irish coders may have been less rigorous than the Portuguese in judging responses as meaningless or referring to them as inadequate. Cross-country coding would resolve the issue.

4.3. Dutch results

The contrasts observed between the Portuguese and Irish responses are even more noticeable in the case of the Portuguese and Dutch data. This is especially clear with regard to question 1. As shown in Table 10, meanings referring to the correspondence/dependency relationship – predominant in Portuguese responses – were given by only three students. Half of the group gave a response broadly in the "formula" category. Almost as many gave responses referring to a "task", "problem solver" or "calculator"; these appear to refer to specific aspects of the approach in the Dutch curriculum. The machine-type analogy, prominent in the Irish data, is not reflected here. Language issues in translating from Dutch, for example in trying to capture approaches to problem-solving, may have exacerbated the contrasts; further discussion and shared coding might resolve some of the difficulties.

Table 10. - Frequency of answers from Dutch participants to question 1

Meaning of the term function	Total

Correspondence/Dependency relationship	3
Machine	0
Formula/rule	18
Task/problem solver/calculator	17
Meaningless/other	6
No reply	0
Total	44

Because of these difficulties, analysis of the Dutch data is still a work in progress, and data from other questions are not tabulated. However, it can be said that the responses to question 4 do not greatly feature the static, set-theoretic approaches that figure for the other two countries, nor do they make heavy use of the machine analogy popular with Irish respondents; in the Dutch sample, an approach via formulae is prominent. This appears consistent with the curricular traditions. The differences regarding question 2 are less marked.

Further examination is left for a later phase in the study. It could also lead to a separate investigation, in which the Dutch curriculum and approach to teaching could play the leading role.

5. Discussion and Conclusion

This paper has described the initial, exploratory phase of a small-scale cross-national project intended to investigate meanings that prospective teachers give for the term "function" and representations that they associate with it, hence hopefully contributing to enhancements in teacher education programmes. Data were collected by means of a short instrument from opportunity samples of prospective mathematics teachers in institutions in Portugal, Ireland and the Netherlands. The data sets from each country were subjected to content analysis by the research team members responsible for collecting them; coding was guided by the data and local curricular issues as well as by the literature. This led to some differences in approach. These would provide a serious problem if the aim of the study were to compare responses from representative samples in each country; cross-country coding and discussion would be needed, as would explication of some language differences. However, especially for the exploratory phase of the study, such an approach was not essential. Rather, even allowing for the

difficulties, the work done has already revealed the capacity of the instrument to elicit meanings and representations of varying degrees of appropriateness and reflecting different curricular traditions. This can lead to within-country exploration of prospective teachers' relevant knowledge as well as providing some cross-country pointers to areas of interest.

Further work is planned, within and between countries. For example, as indicated above, more exploration of the Dutch responses is warranted. Also, it is intended that data be collected by team members in the USA and Germany, hopefully involving prospective science teachers. There is scope also for a deeper study of science and mathematics curricula and analysis of relevant textbooks pertaining to the school year in which the function concept is introduced. This could help to illuminate difficulties, different representations used and conceptions likely to be held by students, and hence by prospective teachers of science and mathematics.

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Popularizing the Scientific Enterprise in Nigeria Towards Actualizing 2030 Agenda in Education: Focus on Science Teaching

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Abstract

There is evidence of increasing gap between the quantity and quality of scientific enterprise in developing countries of the world. Consequently, up till now science policy statements as well as the desire and the ability of Nigeria citizens to bridge this gap has proved abortive. Nevertheless, this study offers a framework for thinking about reconciling the demand and supply in the sciences and reveals a better approach to cultivating such equilibrium. Therefore, this study employed the descriptive survey research method using one sample t-test analysis to determine the significant roles of science teaching on scientific enterprise in Nigeria. It also examines basic needs of science teaching for Nigerian of all ages.

Keywords: Scientific, enterprise, demand, supply, Nigeria, education

1. Introduction

Quality education is one of the global goals that make up the 2030 agenda for sustainable development. In line with Kariuki and Kay (2017), it is high time that nations like Nigeria began to understand that development does not necessarily coincide with the possession of nuclear weapons or the capability to launch satellites. The result which is likely to result in heavy economic and political costs where many basic human needs such as shelter, food and drink, clothing, safety, health and education lacks the required support. However, this kind of development should rather involve industrial systems and education that is powered by scientific enterprise. This is far from the assumption that nuclear energy or space exploration, would somehow convert developing countries such as Nigeria to the 21st century industrialized nation.

More so, individual nations should not expect to follow the research model that culminates into scientific enterprise elsewhere. Instead, following the submission of Guerrero, Crites, Hovermill, and Beaudrie (2018), Nigerian will need to adapt and develop technologies that are endemic, strengthen education and expand the roles of scientists in both government and industry. This will prevent brain-drain by allowing practitioners to be in touch with the problems of their own country. It will also limit the quest or urge to be in search for greener pasture in the pursuit of their personal and career prospects. Therefore, on this note, this study reviews

(i) Scientific enterprise in developing countries

(ii) Scientific enterprise for Nigeria of all ages

2. Scientific Enterprise in Developing Countries

Scientific activity is one of the main features of the contemporary world and; perhaps more than any other, distinguishes the present time from earlier centuries. Modern society according to Dass (2005) is faced with numerous choices, issues and dilemmas resulting from advances in science and technology. In order to make wise choices, resolve issues and vote intelligently, citizens of modern society must be scientifically literate in the sense of understanding the nature of scientific enterprise. Also, in line with Osborne, Collins, Ratcliffe, Millar and Duschl (2003), we are in a society where science increasingly permeates the daily discourse, and so some understanding of its underlying epistemic values, methods and institutional practices. This means that the nature of scientific enterprise is essential if citizens are to engage with the issues confronting contemporary society.

Dass (2005) showed that the influence of science on modern society has rapidly increased at the latter half of the twentieth century when scientists started serving an important role of advisory to policy makers and as communicators of scientific work to the populace. This role has tremendously influenced appropriate policy decisions, ensuring continued funding and support for scientific research, and as well attracting more people to scientific careers. In another study, Raman (2008) argued that the primary aim of science is neither to discover useful results which may be applied for practical purposes, nor is it to make life more comfortable for humankind. In other words, it is possible for a society to be successful in exploiting the practical applications of science

without making any scientific breakthrough. A nation can be productive in industry and successful in technology without any of its citizens engaging in serious scientific research. By implication, weapons of war can be developed, diseases can be cured even where there are no centre for pure scientific research.

Scientific enterprise therefore is necessary for the advancement of knowledge about the world, and not for the application of already discovered knowledge. Science as an enterprise has individual, social and institutional dimensions according to Goldemberg (2003). In the essay he revealed that in developing countries, the practical need which means the demand does not measure up with supply which is the type of pure research that is done to meet those demands. As a result, universities and research centre have become isolated in their own country and connected with research centre elsewhere than to the obvious needs of industry, Agriculture and education in their own country.

3. Scientific Enterprise for Nigeria of All Ages

The vitality of the scientific tradition and its positive impact on society according to Abd-El-Khalick and Lederman (2000) depends on children being successfully introduced to its achievements, methods, and thought processes, by teachers who understand and value science. The teaching of science in school needs reform and should be the type that can build a bridge to the future in line with the submission of Irwin (2000) that science is a kind of subject that should be taught with change in mind. It is necessary to teach science in a way that allows the student to think freely and not just read boring facts from text books.

Education in the sciences according to Pollack (2000) ought to result in more than rote memory of scientific facts and practice of a few scientific processes such as observing, measuring, and using the microscope. According to Leshner (2007) supply and demand must ultimately be reconciled within science policy Institutions, such as relevant government agencies, legislative committees, executive officers, non-governmental advisory groups, for the conduct of research and the utility of results for the betterment of the society.

4. Research Question

What is the significant role of science teaching on scientific enterprise in Nigeria?

5. Methodology

The study adopted descriptive survey research design to carry out an assessment survey for the significant role of science teaching on scientific enterprise in Nigeria. Population of the study includes all secondary school science teachers in Ado-Ekiti, Ekiti state, Nigeria. Simple random sampling technique was used to select two hundred (200) teachers while scientific enterprise need assessment survey instrument (SENASI) with reliability coefficient of 0.86 was used to collect data on relevant items. Data collected was analyzed using one sample t-test analysis to determine the significant role of science teaching needs on scientific enterprise in Nigeria.

6. Results and Discussions

Table 1 - One sample T- test statistics of science teaching needs assessment

One-Sample Statistics

Items	N	Mean	Std. Deviation	Std. Error Mean
Technology in the Classroom	200	15.01	3.835	.271
Science Activity/ Engagement	200	17.7900	4.77282	.33749
Science Policy	200	15.3800	4.12562	.29173
Institutional Infrastructure	200	24.1800	2.57698	.18222
Professional Development	200	33.4300	4.81049	.34015
Job satisfaction	200	32.1300	5.44992	.38537
Behavioral Management	200	17.6750	4.40641	.31158

One-Sample Test

Items	Test Value = 0					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Technology in classroom	55.359	199	.000	15.010	14.48	15.54
Science Activity/Engagement	52.713	199	.000	17.79000	17.1245	18.4555
Science Policy	52.721	199	.000	15.38000	14.8047	15.9553
Institutional Infrastructure	132.697	199	.000	24.18000	23.8207	24.5393
Professional Development	98.279	199	.000	33.43000	32.7592	34.1008
Job Satisfaction	83.375	199	.000	32.13000	31.3701	32.8899
Behavioral Management	56.727	199	.000	17.67500	17.0606	18.2894

Table 1 shows the significant roles of the items on the needs assessment in order of importance having Institutional infrastructure as (t-Cal=132.69> t-Crit =1.960), (P<0.05), followed by Professional Development as (t-Cal=98.27> t-Crit =1.960), (P<0.05) while Job satisfaction as (t-Cal=83.37 > t-Crit =1.960), (P<0.05). Behavioral management as (t-Cal=56.72> t-Crit =1.960), (P<0.05), Technology in the classroom as (t-Cal=55.35> t-Crit =1.960), (P<0.05), Science policy as (t-Cal=52.72> t-Crit =1.960), (P<0.05) and Science activity and engagement as (t-Cal=52.71 > t-Crit =1.960), (P<0.05) respectively. It should be noted that all items on the needs assessment are significant to science teaching and as well to the development of scientific enterprise in Nigeria.

The results supported the findings of Duschl (2003), who found that science has increasingly permeates the society daily discourse, and some understanding of its underlying epistemic values, methods and institutional practices. This means that the nature of scientific enterprise is essential if citizens are to engage with the issues confronting contemporary society. Also, in line with Dass (2005) who discovered that the influence of science on modern society has rapidly increased at the latter half of the twentieth century when scientists started serving an important role of advisory to policy makers and as communicators

of scientific work to the populace. This role has tremendously influenced appropriate policy decisions, ensuring continued funding and support for scientific research, and as well attracting more people to scientific careers.

7. Conclusion

Ideally, science teaching should inculcate in the learner how to think, learn, solve problems and make informed decision. However, this is integral to every aspect of science education including life from school to career and daily activities. It is worthy of note that we are surrounded by science and its products every day and so, science teaching should be given priority in terms of institutional infrastructure, professional development of teachers and policy statements with decisions that affects everyone based on scientific evidence. Therefore, putting into consideration the needs of science teaching being in an increasingly technologically and scientifically advanced world, everyone will be scientifically literate to cope with the trends of the global development.

8. Recommendations

Creation of national institutes that would be broadly interdisciplinary and team oriented, which would apply the methods of science to our difficult social problems.

Government should strive to expand peoples understanding of the enterprise of science and increase appreciation of the way in which science is involved in Nigeria.

Science teachers should be assisted to develop a richer and more authentic understanding of science and its place in the intellectual and social scheme of things.

Students of science and future teachers must be aware of the implications of change and this must be taught within the school setting on constant basis. The teaching of science needs reform and constant review because science changes as we learn more.

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