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The advent of the 4IR demands that we balance equity and excellence in our mathematics education. In the current debates about skills needed in the 4IR, the mathematically gifted have been described as "the world's ultimate capital asset," yet in South Africa reports show that at a time when the educational emphasis is being strongly placed on meeting the needs of the struggling learners, the mathematically gifted learner is often an afterthought. This paper is premised on the view that intervention should start by addressing teacher perceptions of gifted education. Following a quasi-experimental non-equivalent design, 118 Foundation Phase teachers who had not received training on gifted education were surveyed in South Africa. Structured interviews were done with 21 trained teachers in the USA. A comparison of their responses reveals similar findings that trained teachers tend to havepositive perceptions about gifted education than untrained teachers. Our recommendations are that such findings should inform the development of teacher development programs for the benefit of our mathematically gifted students.

Keywords: fourth industrial revolution, mathematically gifted, equity and excellence in mathematics education, teacher perceptions.

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I. INTRODUCTION

Today South Africa finds itself at the threshold of the Fourth Industrial Revolution [4IR] also known as the 21st knowledge-based economy [KBE]. The change brought about by this revolution is impacting all disciplines, all economies rich and poor and all industries advanced and less advanced. This revolution is inevitable, it is not optional, it does not wait for South Africa to address basic literacy and numeracy issues and so its educational institutions needed to not only adapt to this new reality but also be cognisant of the changing expectations of the student body who wants to be a partaker of the good things that it offers. Having adequate levels of education and digital skills capacity and capability is pivotal in ensuring that South Africa maximizes the benefits of the Fourth Industrial Revolution (4IR). The sooner South Africa embraces and fully incorporates the 4IR in the education system, the sooner the stakeholders will realize and begin to teach its learners the critical skills that are crucial for them to remain relevant in this era. So, what does the 4IR mean for the education system in South Africa?

Although education is meant to support the development of a diversity of talents and abilities in the learners; it is not true that equal importance can be placed on all such talents and abilities as we attempt to meet the challenges of the KBE. Within these debates about skills needed for the 21st century KBE, empirical evidence has shown that the positive impact on a country's Gross Domestic Product (GDP) can be isolated mainly to Science, Technology, Engineering & Mathematics [STEM] related achievements as opposed to achievements outside STEM; suggesting that STEM-related achievements are the main drivers of national affluence in the KBE (Tanenbaum, 2016). For this reason, ensuring an adequate supply of STEM skills is at the heart of many governments' strategies for innovation and

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productivity. Some researchers have even gone further to try and establish whether all STEM disciplines have equal importance in the KBE and conclusions have been unanimous that all STEM disciplines require an understanding of mathematics suggesting that "Mathematics is the bedrock of science while science is the necessity for technological and industrial development" (Betiku, 1999:49). Given this bedrock status, mathematics has been described as the subject that drives the KBE hence it should be an important part of any efforts at modern-day technological innovation and development.

But what level of mathematical capabilities matter in the KBE? This question is fundamental to our understanding of the skills needed in the 21st knowledge economy. To answer this question we borrow from MacGillivray (2000) who identified the following three distinctive levels of mathematical capabilities that serve different but complementary purposes in society: (1) the quantitative capabilities of the whole of society or an "at-home-ness" with numbers in the everyday life (2) the mathematical capabilities in the broad spectrum of areas with specific quantitative links; and (3) the high-level capability/expertise of the discipline of mathematical sciences. This categorisation does not in any way suggest that any one of these levels has no place in a modern economy. On the contrary MacGillivray posits that improvements in average performance (level 1) and top end performance (level 3) have separate but complementary effects on economic growth. Level 1 provides a sound foundation or what Fensham (1995) referred to as 'induction into science' while the third level provides what has been described as 'empowerment from science". Admittedly, numeracy is an important starting point, but in today's KBE it is necessary, but not sufficient for students to achieve minimal numeracy competence. Hanushek and Wößmann, (2012) for example, explained the benefits of setting aside the quantity of schooling as a measure of human capital in favor of a qualitative measure of 'cognitive skills'. Their proposition was that not only do we need to have equity and close the famous achievement gaps, we also must have innovation if we are going to survive in the 21st knowledge-based economy (KBE). In South Africa, the demise of our mathematical learners has been attributed to current practices where our achievements in education have always been measured from a social equity perspective. Such achievement measures have tended to focus our attention to the "minimums" of mathematical capability, resulting in us overlooking the "maximums". Given this complimentary role of levels 1, 2, and 3 of mathematical ability, our argument is that South Africa must have an equitable educational provision for all learners which accommodates the below average, the average and the above average who have the potential to achieve the second and third levels of mathematical capabilities which are currently missing. Hence South Africa should urgently begin to strike a balance between equity and excellence in mathematics education.

II. LITERATURE REVIEW

Most countries now recognise that beyond the achievement of basic competences, students also need to develop critical literacy and numeracy skills (level 3) of the kind required for effective functioning in the 21st knowledge-based economy. But how best can an educational system enhance the development of this level 3 mathematical skills? To answer this question, we borrow from Jenkins (1981), who argued that if you are concerned with improving the output of some complex system, [such as education] you must study the component that produces the largest variance first. So which component of mathematics students would produce the largest variance in terms of level 3 skills? We take a quote from Terman (1919) who argued that: *the future welfare of the country hinges in no small degree upon the right education of . . . superior children. .....Moderate ability can follow, or imitate, but genius must show the way.* A similar view is that the progress of human civilization is based on scientific, technological, educational, moral, political, and commercial achievements of the minds of its most talented individuals (Daniels, 2012). Several authors have implicitly or explicitly referred to these superior children with potential for this level 3 capability. For example, in Terman

studies children in that level were colloquially referred to as "termites", Fensham (1995) referred to it as the 'intellectual class', Florida (2012) used the term 'creative class', Hanushek and Wößmann, (2012) spoke of 'rocket scientists', Pritchett & Viarengo (2009) referred to them as 'global performers', and La Griffe du Lion (2004) called it the 'smart fraction' of the population. La Griffe du Lion (2004) then used his 'smart fraction theory' to show that there is a much stronger correlation between high national GDP and this level 3 capability than it is with the average cognitive ability. Other studies have shown that the smart fraction (or gifted or high ability fraction) is not only more relevant than the average cognitive ability level or the non-smart fraction's level on intellectual outcomes but also on non-intellectual outcomes such as criminality, health, government effectiveness, democracy, rule of law and political liberty. In terms of human capital development, Terman's Genetic Studies and the longitudinal Studies of Mathematically Precocious Youth—SMPY are arguably among the most famous longitudinal studies in psychology to date that have tracked mathematically gifted youth for more than five decades with the aim of affirming this thought (Mhlolo, 2017). Results from these studies have confirmed beyond any reasonable doubt that mathematically talented males and females indeed became the critical human capital needed for driving modern day, conceptual economies. From this perspective, the mathematically gifted have been described as "the world's ultimate capital asset" due to their unique potential to become tomorrow's scientists, inventors, entrepreneurs, engineers, and civic leaders in a knowledge-based economy. So, both the smart fraction theory and the intellectual class hypothesis suggest that our future depends crucially on how we educate the next generation of people gifted (intellectual class or smart fraction) in the mathematical sciences. This view is echoed in the more recent South African curriculum documents where inclusivity is now foregrounded and the gifted learner is mentioned as one category of exceptionality that should become the central part of the organization, planning and teaching at school (Department of Basic Education, 2011).

This is even more urgent in the public schools of South Africa where most gifted learners from poor backgrounds attend school. Critics argue that low-quality mathematics education (especially for the poor) becomes a poverty trap from which it is almost impossible to escape. In South Africa, studies have shown that a vast gap persists between the quality of mathematics education provided for and the achievement of White and African students (Maree, 2018). Post-colonial reform in education aimed at reversing such evils of Bantu Education - an education 'for ignorance' where blacks would be taught to develop "manipulation skills" and to have an interest in the soil. An inquiry into how far post-colonial education has closed the poverty gap between blacks and whites, of necessity must therefore begin with an examination of mathematics education - given that the philosophy and ideology of apartheid deemed it absurd to teach a 'Bantu' child mathematics. Admittedly such statements evoke strong emotions but the stark realities of mathematics education in South Africa today require our stakeholders to take the bull by its horns. Have we really reversed that absurdity? Even if we argue that the system has increased accessibility to mathematics education, can we really be proud that our African graduates will compete favorably in the 4IR? We need to constantly take stock of our political history versus our post-colonial vision lest we 'covertly perpetuate' the very same philosophy and ideology of 'absurdity' in teaching mathematics to poor black South Africans. Heuser, Wang, & Shahid (2017) for example pointed to the important role that policies can play in the translation of a vision into practice, sometimes with unintended or inverse consequences. They argue that poorly aligned requirements of certain policies, created out of concern for social equity, might actually create practical limitations to the provision of more inclusive programs for gifted learners from poor backgrounds resulting in another unintended 'covert exclusion'. An important principle is that whatever we do in education, we should remain pragmatic, not doctrinaire, in our approach. We should, as the Chinese would say, 'seek truth from facts'. Where the evidence shows that we are not achieving what

we set out to gain, we change methods. Where the aims are no longer relevant to circumstances, we revise the aims. In a 2019 synthesis report on the National Higher Education Conference, the Dean of Students affairs [Wits], Jerome September is quoted as saying "... enhanced access and success for disadvantaged and excluded communities equalize the life chances of talented individuals, irrespective of their social origin or financial capacity".

Yet in South Africa reports show that the plight of the gifted learner is seldom mentioned (Kokot, 2011) and that far too many of the gifted from poor backgrounds currently do not stand even the remotest chance of achieving up to near their potential (Maree, 2018). In post-apartheid South Africa education, stakeholders have been hostile to and resentful of gifted education programs which are critical for academic talent development (Kokot, 2011). Speaking at the launch of the Tshawaga Region Maths and Science Teacher Strategy on 31 January 2015, the then UNISA Vice-Principal of Research & Innovation and Professor of Mathematics Mamokgethi Phakeng said: "Unless we increase the quantity and quality of learners who can become the next generation of scientists, engineers and technical specialists, South Africa's vision for a sustainable democracy will not come to fruition". In the preamble of the National Development Plan (Vision 2030) - the National Planning Commission envisages a South Africa where we participate fully in efforts to liberate ourselves from the conditions that hinder the flowering of our talents. The plan goes on to state that schools are where talent is identified, career choices made, and habits learnt.

These calls suggest that we must be concerned about the education of our gifted students in the STEM subjects in general and mathematics in particular. But how best can we respond to these calls? Informed by the research conducted, Spaull (2013) developed four points that must be borne in mind in addressing South Africa's numeracy and mathematics schooling challenge, that (i) although the improvement of mathematics teaching and learning in public schools will not happen fast, it must begin urgently; (ii) poor mathematics and numeracy teaching and learning in public schools accelerate private schooling wherein there is enrolment growth in private extra mathematics lessons; (iii) if South Africa is to be realistic about having a knowledge economy and creating more and better jobs, it will require a sustained focus on teacher and teacher-training development, particularly in mathematics teaching, and (iv) in the interim, it is likely that the country will have growing numbers of innumerate young people, and a majority of young South Africans could be unqualified to be hired in many types of high quality work.

III. PROBLEM STATEMENT

This paper might not have all the relevant answers to concerns raised by Spaull, but it builds on the view echoed in a UNESCO maxim that an education system is only as good as the quality of its teachers because the teacher is viewed as being at the core of quality. With specific reference to mathematics education, Leikin (2011) posits that teachers are the agents of the educational system who should design mathematical challenges appropriate for all the students in general and particularly for the mathematically gifted ones. Hence it can be argued that teachers can either make or break the education system for gifted students. In South Africa, teachers interviewed by Oswald & de Villiers (2013) unanimously concurred that they had never received training on how to identify and support gifted students prompting the authors to recommend that the quality of gifted education is dependent upon the quality of training the teachers receive. Similarly, Kokot (2011) posits that teacher colleges and universities exert direct influence on the education of gifted children by training (or not training) future teachers. Her recommendation was that these institutions should be the major focus of advocates for improving gifted education.

The research project from which this paper draws data responds to that recommendation in that it aims at developing a teacher training program for teachers for the gifted. It shares the view by Davis and Rimm (2004) that the first question to be asked when devising a programme for teachers for gifted learners should be: What is our teachers attitude towards gifted children?

IV. RESEARCH QUESTIONS

It is against this background that we raised the following research questions:

- What perceptions do mathematics teachers hold before receiving training on gifted education?
- What perceptions do mathematics teachers hold after receiving training on gifted education?
- How can the similarities or differences help to shape teacher training programs for the mathematically gifted learners?

V. IMPORTANCE OF THE STUDY ON TEACHER PERCEPTIONS

In this study, we hypothesized that teachers who have training in gifted education or experience as gifted education teachers would have more positive attitudes toward gifted education and gifted students. Further, we hope that the outcomes of this study will aid in preparing and revising teacher preparation program curricula to better meet the educational needs of Foundation Phase school teachers and for them to meet the educational needs of mathematically gifted learners in their classes. A study by Geake and Gross (2008) shows that a teacher's unconscious negative attitude can be reduced through professional development courses in which teachers become more familiar with the characteristics of gifted students and their learning needs. This paper was premised on this view that teachers' negative attitudes can be reduced through professional development hence we wanted to evaluate the perceptions teachers hold before receiving training and after receiving training on gifted education.

In developing a successful teacher development programme for teachers for the gifted, stakeholders must identify what teachers know and believe about gifted children and their education. In particular, they should be explicit about whether their teachers are interested in and supportive of gifted education. A negative attitude and prejudice can cause discriminatory behaviour, particularly when it exists within a group of teachers (Bohner & Wänke, 2002). If teachers develop positive attitudes towards giftedness, they are more likely to be supportive of gifted education, and to be effective in identifying and catering for gifted students. Research shows that teachers, trainers, and education specialists execute programs of gifted education in accordance with their own level of training, and their perceptions and dispositions can serve as important catalysts or barriers (Heuser, Wang, & Shahid 2017). In many developing countries, there are hostile and negative stereotypes that shape teachers' attitudes and expectations regarding gifted students – attitudes and expectations that become barriers to the process of learning and belie the egalitarian ideals that form the philosophical foundation of many schools. Therefore, if the negative attitude of teachers about gifted students is not changed through training, they are likely to retain this attitude in their professional practice.

VI. METHOD

6.1 Context of the research sites

Perceptions of teachers before training on gifted education were collected from Foundation Phase Teachers in 20 schools in the Free State Province of South Africa. The Foundation Phase ranges from Grade R (the reception year) to Grade 3. Foundational Phase teachers usually teach all the subjects in the curriculum to learners, whereas teachers in the higher phases teach only certain subjects in which they specialize. Perceptions of teachers after training on gifted education were collected at a university in the USA after attending their 3-week summer programs for gifted students. Their two summer programs are:

- Verbally and Mathematically Precocious Youth (VAMPY) catering for Gr 7 – 10 learners.
- Camp Innovate caters for Gr 3 – 5 learners.

Literature suggests that it is useful to work with pre-existing groups because they provide one of the social contexts within which ideas are formed and decisions made" (Kizinger, 1994:105).

6.2 Research Design

In this study we employed a Quasi-experimental *non-equivalent groups design* (NEGD). Quasi-experimental designs identify a comparison group that is as similar as possible to the treatment group in terms of baseline (pre-intervention) characteristics. The comparison group captures what would have been the outcomes if the programme/policy had not been implemented (i.e., the counterfactual). Hence, the programme or policy can be said to have caused any difference in outcomes between the treatment and comparison groups. In this case we chose experimental group 1 comprising teachers from Free State in South Africa who are not trained on gifted education. We chose experimental group 2 comprising teachers from the USA who have received training on gifted education. In quasi-experimental designs, the programme or policy is viewed as an 'intervention' in which a treatment – comprising the elements of the programme/policy being evaluated – is tested for how well it achieves its objectives, as measured by a prespecified set of indicators. In this case training of teachers on gifted education in South Africa (treatment group) is viewed as an intervention which should change their perceptions and support of gifted learners in their schools.

6.3 Participants

In accordance with the non-equivalent group design, two sets of participants took part in this study. The first group comprised 118 Foundation Phase Teachers selected from 20 schools from both Xhariep and Motheo districts of the Free State in South Africa.

Table 1: Biographical information about participants (n = 118)

Gender	
Male	2
Female	16
Race	
Black	118
White	0
Coloured	0
Indian	0
Age Group in years	
21 – 30	14
31 – 40	13
41 – 50	40
51 – 60	51
Years of experience	
0 – 5	29
6 – 10	18
>10	71

This group represented the untrained teachers. Our definition of 'untrained' is specifically with reference to training on gifted education. Our view based on literature available is that in South Africa there are no teacher training programmes both pre-service and in-service for teachers for the gifted students. We therefore assumed such a group would provide us with some insights on how gifted education is viewed before one receives training on gifted education.

The second set of 21 participants comprised 1 VAMPY teacher, 3 VAMPY assistant teachers, 2 practicing teachers for the gifted, 1 Camp Innovate teacher, 1 district coordinator for gifted education, 1 educational psychologist, 1 educational counselor, 1 assessment specialist on

gifted education, 1 advocate for gifted education, 1 former elementary school principal with a gifted education endorsement, 1 current pre-service student on the gifted education programme and 7 VAMPY students. The USA does not use similar biographical categories like South Africa but suffice to say that there were 2 male and 19 female participants. This group would provide us with some insights on how gifted education is viewed after one receives training on gifted education.

6.4 Data collection procedure

We used a mixed method approach to collect data, where 118 participants responded to a questionnaire and 21 participants from the USA responded to a structured interview. We wanted to compare perceptions teachers have before receiving training on gifted education and those perceptions after receiving training.

VII. FINDINGS

Let us recall that our first research question was: What perceptions do mathematics teachers hold before receiving training on gifted education? The following tables and figures give responses on different aspects related to gifted education.

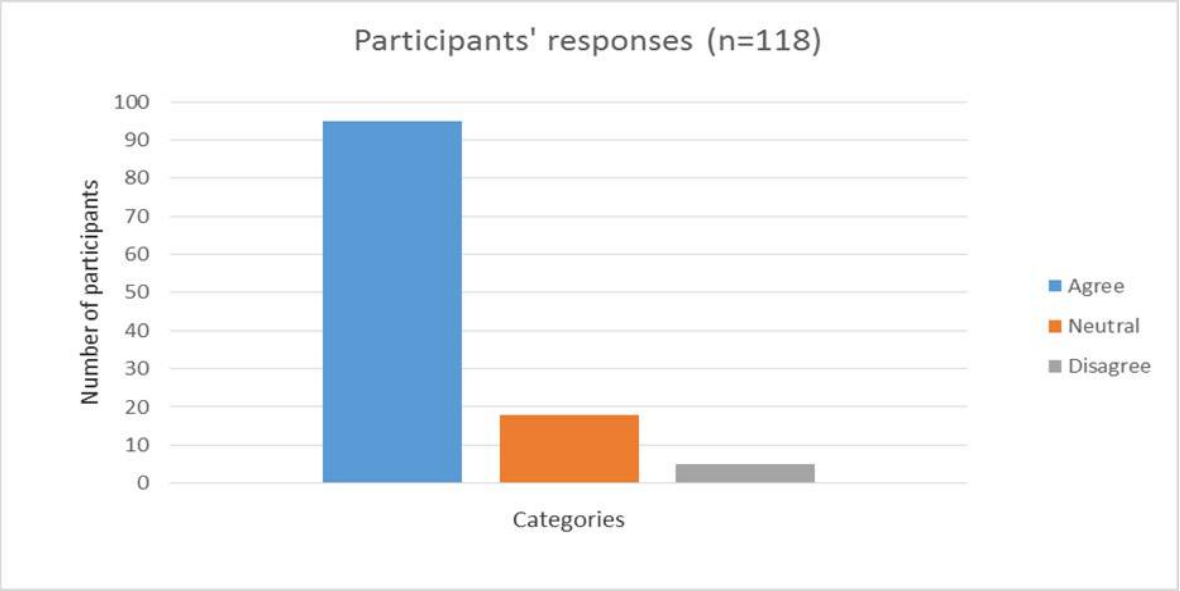

Figure 1: Do untrained teachers believe they have gifted learners in their classrooms?

We first asked teachers whether or not they have gifted learners in the classrooms. Figure 1 shows that 95 teachers agree to having gifted learners in their classes, 18 teachers are neutral to the statement and 5 of them disagree. This is an indication that the majority of teachers recognize the presence of gifted learners in their class according to their different characteristics. Various indicators were mentioned by respondents on how they were able to identify such gifted learners.

We were also interested to capture teachers' perceptions on whether or not gifted students should be of concern to them and why. Literature abounds of the myths that prevent teachers from appropriately educating millions of advanced students. The National Association for Gifted Children [NAGC] compiled a list of the most prevalent myths in gifted education with evidence rebutting each of them. We borrowed 6 of them and developed some statements and asked our participants to tick each of them that they agreed with. Participants were asked specifically to tick all of those statements that they agreed with.

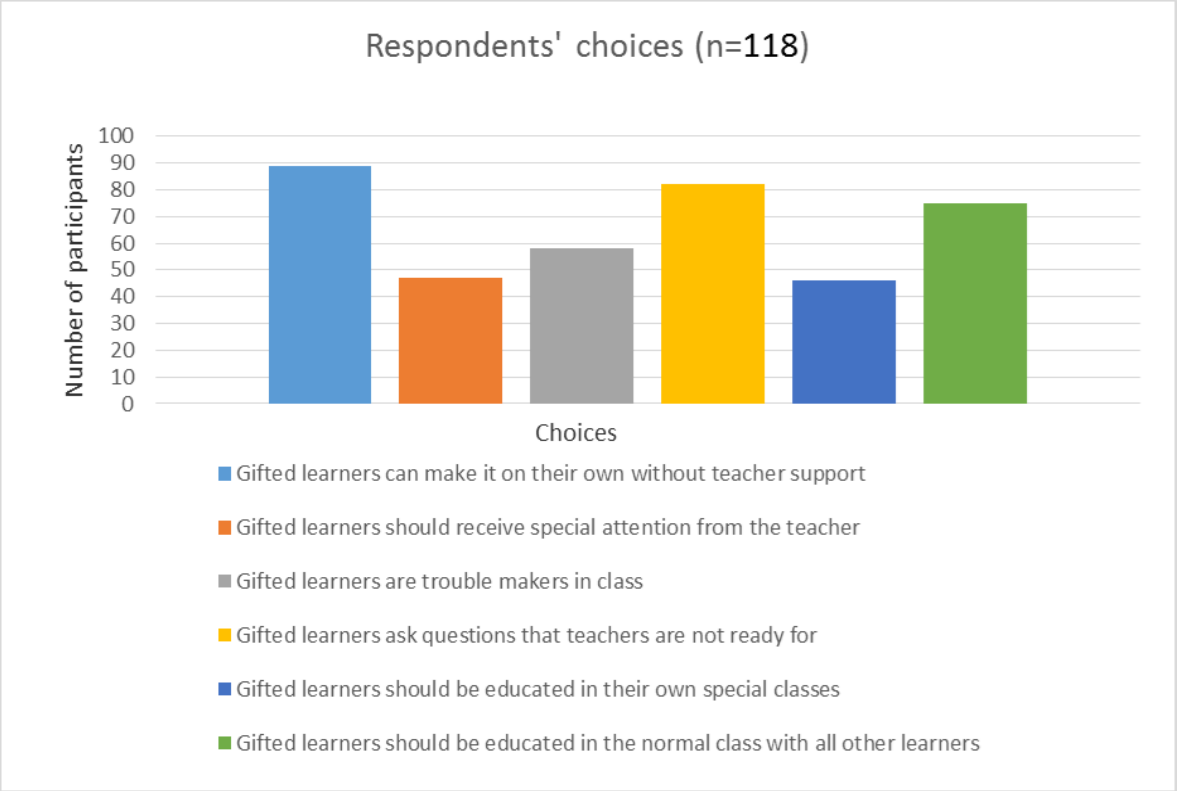

Figure 2: Perceptions of teachers before receiving training on gifted education

As shown in figure 2 there are 89 teachers who chose, "gifted learners can make it on their own without teacher support", 47 teachers chose, "gifted learners should receive special attention from the teacher", 58 teachers chose, "gifted learners are trouble makers in class", 82 teachers chose, "gifted learners ask questions that teachers are not ready for", 46 teachers, "gifted learners should be educated in their own special classes" and the last choice consists of 75 teachers, who chose "gifted learners should be educated in the normal class with all other learners."

We also solicited for responses on what untrained teachers perceived as teacher-related barriers to the education of gifted education. Table 1 captures the responses.

Table 2: What untrained teachers see as barriers to gifted education

Teacher	Response
1020	The teacher who is not preparing well everyday
1021	Teacher development. Teachers must be well trained to deal with such learners. They must be trained concerning their behavior and activities that can be used to keep them meaningfully busy. Lack of information from the teacher or parents to deal with such learners. Teachers consider them as restless learners in the classroom and just need punishment.
1024	Little or no special training is given to educators as to how to deal with such learners.
1028	Well-trained educators
1054	Lack of experience in teaching gifted learners
1074	Lack of quality education can be a barrier to such learners.
1075	Lack of sufficient subject matter. Subject matter knowledge becomes critical for educators working with gifted learners. Lack of content knowledge also affect the use of important pedagogy.
1089	Lack of teacher training for such learners.

Consistent with our assumptions that untrained teachers would still be able to recognise that they have gifted learners in their classes, we also solicited for responses on what grouping strategies they used to meet the needs of such learners. Figure 4 captures the responses.

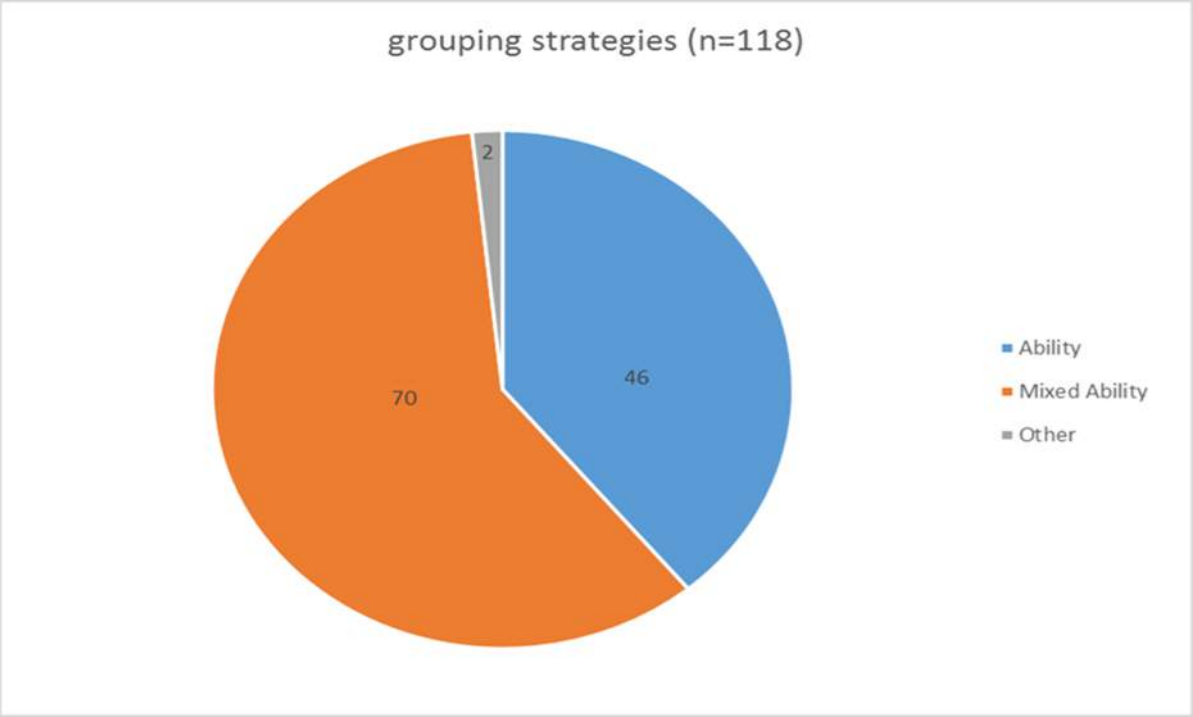

Figure 4: What grouping strategies do untrained teachers use

Figure 4 shows that 46 (39%) teachers group their learners according to their ability. The majority of 70 (59%) of the teachers group learners according to mixed ability. The remaining 2 (2%) of teachers chose "other" for the following reasons below:

Our second research question was: What perceptions do mathematics teachers hold after receiving training on gifted education?

Let us recall that data to answer this question were collected through structured interviews given the diversity [teachers, counselors, psychologists, advocates, trainees etc.] and number [21] of the respondents in the USA. It is therefore not possible to capture such qualitative responses in tables and figures as we did with the first research question. We will however present the qualitative findings in the discussion section of this paper.

VIII. DISCUSSION OF RESULTS

Within the perceptions that untrained teachers hold, we were interested to know if they believe they have gifted learners in their classes. The results of our study show that 80% of the respondents agree to having gifted learners in their classes. We asked a similar question to a trained advocate for gifted education and in her words, she said:

Gifted children come from all backgrounds, they come from all socio-economic levels, they are boys, they are girls, and we must be looking to make sure that all children have quality educational opportunities and those who demonstrate they are ready for more must have those opportunities on an ongoing basis. We don't want to limit anyone. Diversity must be represented in all services for gifted children because we know that gifted children do come from all backgrounds.

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A concern that has always been leveled against gifted education programs is that such programs favour learners from advantaged backgrounds. As a result, democratic governments, whether long established or newly formed, often have reservations about special programmes that meet the needs of only a few - particularly when those programmes expand the gifts of the already privileged individuals. The inevitable connotation of giftedness as associated with elitism demands that the tension between equality and differentiation take the centre of analyses of gifted education policies and programs, which can lead to the intentional avoidance of formally defining and providing for gifted students in some countries such as South Africa. In South Africa for example, many researchers have shown how the rise in private schooling has been fuelled by the poor education in public schools which serve the poor prompting the view that efforts at eliminating 'overt exclusion' have created another form of 'covert exclusion' of gifted learners from poor backgrounds.

One of the main challenges that will affect the successful implementation of the 4IR in education in South Africa is giving learners from previously disadvantaged communities new 21st-century skills (Meyer & Gent 2016). Consequently, the associated risk of the 4IR for our education is inequality. Inequality within the education sector in South Africa is a highly sensitive topic, and new technological developments have the potential to perpetuate this notion. There is a high risk of only the wealthy portion of the population being able to become relevant in the 4IR while the poor population is left behind. Hence, a bigger inequality gap between the "haves' ' and "have nots" will create further alienation, lack of trust, and social unrest. Consistent with the view of giving learners from previously disadvantaged communities new 21st-century skills, the WKU team provided us with an experience of how they work with gifted learners from less privileged communities. They took us to an off-campus summer math school in partnership with Bowling Green County Education, funded by Dupont, for gifted students from three schools in low socio-economic communities. For the whole week gifted learners were bused into the school and given an opportunity to meet like minded learners.

We were also interested to capture teachers perceptions on whether or not gifted students should be of concern to them and why. Our results show that the majority of teachers believe that gifted learners can make it on their own. We asked a trained teacher in the USA a similar question and here is what she had to say:

So, I would say that a lot of my reason for choosing to study gifted education, is just the lack of representation that gifted populations have, I think a lot of times, I'm not sure if this would be true in your culture as well. But I think a lot of times people see it as a luxury. Like, we've got to get these kids that aren't getting it. And then those that already have it, they'll be having fun. And so that, for me, I was one of those. So, for me, that is not fulfilling. And that did not keep me challenged throughout my own education. And I would say you probably have a similar experience.

The second largest response to this same question was that gifted learners ask questions that teachers are not ready for. So, we also asked trained teachers in the USA what was challenging when working with these students and here is what they had to say:

Teacher 1:

They grasp things so quickly and they ask too many why questions. They want to move on these challenging problems that I put up. These are problems that I think will take them a long time to do, but quickly they're done. Yeah, 10 minutes, I expected it to take them a couple hours, 10 minutes, they've got the answer.

Teacher 2:

I think the most challenging part of working with gifted children is they can grasp things so quickly, ... I have a student who has already finished one book and is about a third of the way through his second book. And he's still doing all these challenging problems. He can often see the answers really quickly.

Researcher 1

You must be way ahead of them

Teacher

Yes. And there are times that he asked me questions where I just have to say, I don't know. Can I look at this and get back to you later? Yes.

Researcher 2

So, what do you do in that case?

Teacher 1:

In terms of why questions, I can acknowledge the question and defer answering it until later. In terms of finishing work too quickly I give them more. We have to over prepare so much for this, because they can just move through them very quickly. And so, with this group, they have their book work that they can do. And that is all individual, whatever they're working on. So, they have different textbooks. And then even those who have the same textbooks, they're often at different places in those books. And then on the challenging problems they work together. But, they just can move so quickly. So, this is the beginning of the third week. I have a student who has already finished one book and is about a third of the way through his second book. And he's still doing all these challenging problems. He can often see the answers really quickly.

Teacher 2:

You need to make use of that information without making them feel bored with the very basic stuff.....Gifted children know themselves a lot better than we give them credit for so. I asked her: Do you want some more? and she said give me. So, she is busy working on that for one more hour.

We were also interested to know from the untrained teachers what could be teacher-related barriers to the education of gifted learners. Although couched differently, the overall observation is that teachers feel:

Lack of sufficient subject matter. Subject matter knowledge becomes critical for educators working with gifted learners. Lack of content knowledge also affects the use of important pedagogy.

We asked a similar question to the trained teachers for gifted learners in the USA and here is what they had to say:

Teacher 1:

I have a PhD in math. So, bachelor's degree in math education, Masters and PhD in math.

Teacher 2 & 3:

We are two practicing teachers (and friends) who have recently completed our Masters in Gifted and Talented Studies.

IX. PROGRAM COORDINATOR

I had them as brilliant undergraduates in mathematics.

One other question we asked untrained teachers was about grouping strategies which they preferred. The majority 60% favored mixed ability grouping. We wanted the teachers to justify their choice of the grouping strategy and 77% of those who chose mixed ability grouping suggested that the strategy allows the gifted to help and motivate the slow/struggling ones or others as well as learning from others and sharing ideas, mixed ability grouping helps gifted learners because others can learn from them while exchanging ideas as they help fellow learners with barriers. Instead of just asking teachers who trained on gifted education to give their view on grouping strategies, we captured the gifted learners' views about the matter.

Table 3: Informal talks with the VAMPY students

Learner	Comments
CSw	I love coming to VAMPY because I can ask all my questions and I get answers. It is really interesting to see how everything around us works and how we can manipulate it to our advantage.
AH	I love math. I have spent three weeks doing math because I love it and I want to be exposed to this community that wants to learn and love math as much as I do.
LH	The best part is working on projects because I meet new people and I am also contributing something.
DJ	In this camp, you can pick anything, and you will get many different viewpoints, but everyone will listen.
LK	We are one big happy family, we belong. That is what I love so much about VAMPY.
CS	We are not just doing a curriculum because we must, we discuss work that is aligning with our interests.
BL	Our home away from home. It is so cool to be part of this group that is thinking and reasoning about things like I do. It is ok to ask many questions.

Clearly learners find it cool to be part of a group that is thinking and reasoning about things in the same way as them. However, studies on the grouping strategies are not in agreement as to which one could best serve the interest of the gifted students. Much really depends on what the teachers do with their gifted learners during the implementation of any of those strategies. Concerns have been raised, however, with mixed ability grouping where teachers use gifted students as assistant teachers. Similarly Burns and Mason (2002) found that elementary school principals, when creating supposedly heterogeneous class groupings, tended to avoid assigning low-performing students and high-ability students to the same classes because the principals assumed that teachers would gear the instructional pace to the lower portion of the class. Burns and Mason also found that students in the high-ability classes received better instruction, had more motivated or better qualified teachers, and benefited from high-ability classmates who contributed to an improved academic climate.

The last question that we raised with the trained teachers was: What motivated them to train as a teacher for the gifted?

Teacher 4:

I am a gifted student myself

Teacher 5:

My brother is gifted and so I felt the need to help him.

Researcher to teacher 4:

How did you know that you are gifted yourself?

Teacher 4:

I wrote the Scholastic Aptitude Test (SAT) used in the talent searches in the USA.

Results from similar studies have confirmed that a person's self-perception as gifted significantly predicted attitudes toward gifted education in one of the reviewed studies (Michener, 1980), suggesting that those who perceive themselves as academically gifted or who have gifted friends and family tend to harbor more positive attitudes toward the gifted. In addition, contact with gifted children, past participation in a gifted program, the presence of a gifted program in the participant's school, and perceived knowledge of giftedness were statistically significant predictors of attitudes toward the gifted in the majority of studies that included these variables (Bégin & Gagné, 1994).

X. CONCLUSION

In this paper we have shown the important role played by mathematics education in the 4IR. We have argued that while the recognised levels 1, 2, and 3 of mathematical capabilities served different but complementary purposes in the KBE, we need to place (level 3) creativity and innovation in the forefront of our educational systems. In this regard we must be concerned about the education of the mathematically gifted learners, especially those from poor backgrounds. We then argued that teacher preparation is central to our efforts to improve the education of the mathematically gifted learners. We further argued that an understanding of their perceptions before and after receiving training on gifted education would help us shape an effective teacher development programme.

Using a quasi-experimental nonequivalent design, we then took a survey of 118 untrained teachers' perceptions about gifted education. Our definition of untrained is with specific reference to receiving special training on gifted education. This was followed by structured interviews with 21 trained teachers in the USA. The Results of our study show that untrained teachers tend to have some negative perceptions about gifted education such as gifted students do not help. On the other hand, trained teachers tend to be passionate about gifted students. This gives us hope that training of teachers on gifted education is likely to transform their negative perceptions into more positive ones. This in turn is likely to change classroom practices for the better.

XI. RECOMMENDATIONS

We recommend that if a teacher programme for gifted education is to be developed, questions such as what motivates applicants to want to embark on gifted education training should be considered. We also recommend that further studies be carried out with High School teachers. Our view is that Foundation Phase mathematics learners present less challenges to teachers when compared to High School learners.

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REFERENCES

1. Almulla, E. K. & Fateel, M. J. (2017). Pre-service teachers' perceptions of gifted students. *Journal of Teaching and Education,* 06(02):53–70.
2. Bégin J. & Gagné, F. (1994). Predictors of Attitudes toward Gifted Education: A Review of the Literature and a Blueprint for Future Research. *Journal for the Education of the Gifted. Vol. 17, No. 2, 1994, pp. 161-179. C*
3. Betiku, O. F. (1999). Resources for the effective implementation of the 2- and 3-dimensional mathematics topics at the Junior and Senior secondary school levels in the Federal Capital Territory, Abuja. Nigerian Journal of Curriculum Studies, 6 (2): 49–52.
4. Bohner, G. & Wänke, M., (2002). *Attitudes and attitude change*, Psychology Press, Hove.
5. Burns, R., & Mason, D. (2002). Class composition and student achievement in elementary schools. *American Educational Research Journal, 39* (1), 207–233.
6. Davis, G. & Rimm, S., (2004). Education of the gifted and talented, 5th ed., Alyn and Bacon, Boston, MA.
7. Department of Science & Technology (2012). Final Report of The Ministerial Review Committee on the Science, Technology and Innovation landscape in South Africa *Government Gazette, 31 May 2012*.
8. Diezmann, C. & Watters, J.J., (2002). 'Summing up the education of

mathematically gifted students', proceedings of the 25th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 219–226, Auckland.
9. Fensham, P. J. (1995) 'Curriculum emphases in conflict in science education', in D. Roberts and L. Ostman (eds) *The Multiple Meanings of a School Subject: Essays on Science and the School Curriculum,* New York: Teachers' College Press, Columbia University.
10. Florida, R. (2012). *The rise of the creative class revisited* (Tenth Anniversary Edition). New York, NY: Basic Books
11. Geake, J. G., & Gross, M. U. M. (2008). Teachers' Negative Affect toward Academically Gifted Students: An Evolutionary Psychological Study. Gifted Child Quarterly, 52, 217-231. http://dx.doi.org/10.1177/0016986208319704
12. Hanushek, E. & Wößmann, L. (2007). 'The Role of School Improvement in Economic Development' NBER Working Paper 12832, Cambridge, MA: National Bureau of Economic Research.
13. Hanushek, E.A., Wößmann, L. (2012). Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation. *J Econ Growth* **17,** 267–321 (2012). https://doi.org/10.1007/s10887-012-9081-x
14. Hausmann, R. (2016). Economic Development and the Accumulation of Know-how. Welsh Economic Review, 13 – 16. Lewis, E. & Milton, M., 2005, 'Attitudes of teachers before and after professional development', Australasian Journal of Gifted Education 14(1), 5–14.
15. Heuser, B. L., Wang, K. & Shahid, S. (2017). Global Dimensions of Gifted and Talented Education: The Influence of National Perceptions on Policies and Practices. *Global Education Review 4(1) pp. 4 – 21.*
16. Jenkins, J. J. (1981). Can we have a fruitful cognitive psychology? In H. E. Howe, Jr. & J. H. Flowers (Eds.) *Cognitive processes: Nebraska symposium on motivation* 1980 (pp. 211–238). Lincoln, Nebraska: University of Nebraska Press.
17. Jojo, Z. (2019). Mathematics education system in South Africa. In Gilson Porto Jr., (Ed.) *Education Systems Around the World'*, 129-140, Intechopen, London, United Kingdom. https://www.intechopen.com/books
18. Kokot, S. J. (2011). Addressing giftedness. In E. Lansberg, D. Kruger, & E. Nel (Eds.), Addressing barriers to learning: A South African perspective. Pretoria: Van Schaik Publishers.
19. La Griffe du Lion (2004). Smart fraction theory II. 6(2). Retrieved Aug 1, 2020 from www.lagriffedulion.f2s.com/sft2.htm.
20. Leikin, R. (2011). Teaching the mathematically gifted: Featuring a teacher. *Canadian Journal*
21. MacGillivray, H. (2000). Submission to the Australian science capability review. http://www.industry.gov.au/science/review/ChanceSubmissions/ReviewSubs/sub60AMSCmaths.doc
22. Maree, J. G. (2018). Gifted education in Africa. In: Pfeiffer, S. I., Shaunessy-Dedrick, E, Foley-Nicpon, M. (eds) APA handbook of giftedness and talent. APA handbooks in psychology. American Psychological Association, Washington, DC, pp 131–142
23. Meyer, I.A. and Gent, P.R. (2016). The Status of ICT in Education in South Africa and the Way Forward. Centurion: The National Education Collaboration Trust (NECT). Available at: http://nect.org.za/publications/technical-reports/the-state-of-ict-in-education-in-south-africa/
24. Mhlolo, M. K. (2017). Regular classroom teachers' recognition and support of the creative potential of mildly gifted mathematics learners. *ZDM Mathematics Education, 49:81–94.*
25. Michener, L. (1980). A survey of the attitudes of administrators, teachers, and community members toward the education of gifted children and youth. *Dissertation Abstracts International, 41,4678A-4679A. (University Microfilm No. 8 l*-09, 558)
26. Oswald, M. & de Villiers, J. M. (2013). Including the gifted learner: Perceptions of South African teachers and principals. *South*

African Journal of Education, 33. http://www.sajournalofeducation.co.za.
27. Pfeiffer, S. I. (2013). *Serving the gifted: Evidence based clinical and Psychoeducational practices*. New York: Routledge.
28. Pritchett, L., & Viarengo, M. (2009). Producing superstars for the economic Mundial: The Mexican Predicament with quality education. *Program on Education Policy and Governance Working Papers Series*.
29. Spaull N. (2013). *South Africa's Education Crisis*. Johannesburg: Center for Development and Enterprise (CDE).
30. Tanenbaum, C. (2016). STEM 2026 - A Vision for Innovation in STEM Education – A report available on the website at https://innovation.ed.gov/what-we-do/stem/

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